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(UNIVERSITY OF LONDON)
(COUNTY COUNCILS OF KENT AND SURREY).

REPORT

ON

ECONOMIC MYCOLOGY

FOR

1913-14.

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FEB 8 1933
UNIVERSITY OF ILLINOIS

BY

E. S. SALMON, F.L.S., Hon. F.R.H.S.

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E. S. SALMON, F.L.S.

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INTRODUCTORY NOTE.

By E. S. Salmon.

During the past year a very large number of diseased plants have been sent in by farmers and gardeners; these have been examined (and where necessary, cultures of the fungus concerned made), and reports sent to the grower as to the nature of the disease and the remedies.

Among the diseases sent in the following have been the most frequent: Apple "Scab" (*Venturia Pomi*); Apple Mildew (*Podosphaera leucotricha*), Apple "canker" (*Nectria ditissima*); Apple "Brown Rot" canker (*Sclerotinia fructigena*); "Bitter Rot" of Apple (*Gloeosporium fructigenum*); "Sooty Blotch" of Apple (*Leptothyrium Pomi*); Pear "Scab" (*Venturia pirina*); Cherry Leaf Curl (*Exoascus minor*); Peach Leaf Curl (*E. deformans*); Plum *Fomes* (*Fomes pomaceus*); Gooseberry "Cluster-cup" (*Puccinia Pringsheimiana*); American Gooseberry-Mildew (*Sphaerotheca mors-uvae*); European Gooseberry-Mildew (*Microsphaera Grossularieae*); Wheat Rust (*Puccinia glumarum*); Celery "Blight" (*Septoria Petroselini* var. *Apii*); Potato "Scab" (*Oospora scabies*); "Black-leg" of the Potato (*Bacillus phytophthorus*); *Rhizoctonia* of the Potato; Peach Mildew (*Sphaerotheca pannosa*); Rose Rust (*Phragmidium subcorticatum*); Carnation Rust (*Uromyces caryophyllinus*); Willow-rod "canker" (*Melampsora alii-salicis albae*); Wallflower "Mildew" (*Peronospora parasitica*); Tomato "canker" (*Mycosphaerella citrullina*); Cabbage "Leaf-spot" (*M. brassicicola*); Tomato "Rust" (*Cladosporium fulvum*); Bacterial Rot of Hyacinth; *Fusarium* of Apple-buds (see below, p. 64); Fungous diseases of the Loganberry (see below, p. 88); Bacteriosis of the Potato, and *Cytospora* of the Apple (*Cytospora carposperma*).

Complaints of the "Silver-leaf" Fungus (*Stereum purpureum*) have been frequent, more especially from farms

where the reprehensible practice had been followed of allowing old dead " silvered " trees to remain in the orchard or plantation instead of being grubbed up and burnt.

An outbreak of " scab " on potatoes on a farm near Guildford, Surrey, was investigated, and the disease found to be " corky scab," caused by the fungus *Spongospora Solani*. The variety attacked was the " Eclipse," and the infestation was fortunately not severe. This disease has become of considerable economic and practical importance, since the Governments of many foreign countries are now prohibiting the importation of English potatoes unless they are certified as having been grown on land where no attacks of " corky scab," " wart-disease," or bacterial disease of the potato have occurred.

Isolated outbreaks of the " wart-disease " of the potato (*Chrysophlyctis endobiotica*) have occurred in Surrey, and are under the charge of the Board of Agriculture.

A case of " Crown Gall " on Lucerne, caused by the fungus *Urophlyctis Alfalfae*, was found at Malling, near Maidstone.* This is the first case noted in Mid-Kent, the previous ones having all been in East Kent. I am informed that this disease is very frequent in South America, where Lucerne (" Alfalfa ") is so largely grown.

During the past season outbreaks of the " Brown Rot " fungus (*Sclerotinia fructigena*) have been unusually frequent and severe—Cherries, Plums, and Apples being commonly attacked. There seems clear evidence that this fungus is attacking the Apple with greater virulence than previously, and it is now frequently the cause of a " canker " of the stem. (See below, p. 60.)

A considerable amount of attention has been paid to the life history of the American Gooseberry-Mildew (*Sphaerotheca mors-uvae*) ; the manner of the dehiscence of the *perithecium*, and the time at which this takes place, have been ascertained ; these facts which were not previously known are likely to prove of practical importance. Experiments in spraying to keep this mildew in check have been continued with a considerable amount of success. (See below, p. 17.)

* This was brought to my notice by Mr. J. Amos, Superintendent of the College Research Station at Malling.

Numerous enquiries as to the use and properties of the lime-sulphur wash have been received; in several cases samples of the home-made wash have been determined for density.

Samples of Celery seeds suspected of harbouring the *spores* of the Celery "Blight" fungus (*Septoria Petroselini* var. *Apii*) have been microscopically examined for growers.

My assistant, Mr. H. Wormald, has successfully investigated a Bacterial Heart-rot of the Celery, and isolated a bacterium new to Science. A full account of this work appears in the *Journal* of *Agricultural Science*, vol. VI., p. 203, and a *résumé* is given below (p. 71).

Mr. G. Smith and Mr. G. O. Searle, on obtaining their B.Sc. degree in the University of London, commenced research work in the Mycological Laboratory.

Mr. G. Smith has investigated the infection powers of the potato "blight" fungus (*Phytophthora infestans*) (see below, p. 108).

Mr. G. O. Searle, to whom a Research Studentship has been granted by the Board of Agriculture, is working on the specialization of parasitism in *Erysiphe Polygoni*, the Sweed mildew, and has already obtained some interesting results.

THE AMERICAN GOOSEBERRY MILDEW.

(*Sphaerotheca mors-uvae* (Schwein.) Berk.)

By E. S. Salmon.

In past volumes of this *Journal*, I have recorded the gradual spread of the American Gooseberry Mildew in Kent, since its first outbreak in 1908, and also the steps taken by the Kent County Council to attempt to deal with the disease on the lines laid down by the Board of Agriculture's "American Gooseberry Mildew Orders." Owing to the failure of the measures taken to stop the spread of the mildew, the Kent County Council decided, in October, 1913, to refuse to carry out any longer the Board of Agriculture's Mildew Orders. Previously to this, it must be noted, a deputation of fruit-growers from Kent visited the Board of Agriculture under the following circumstances. Early in 1913, the Maidstone Farmers' Club passed the following resolution: "That this Club and Chamber respectfully urge upon the Board of Agriculture that in view of the experience of practical fruit-growers, that tipping gooseberry bushes has been proved to be useless in the prevention of gooseberry mildew, and that the pest can only be dealt with by spraying, the regulations should be modified so as to omit compulsory tipping, and the Club and Chamber would support a more drastic application of the regulations as regards spraying." It is to be noted that during the winter of 1912-13, a number of growers began to evade the compulsory "tipping" of diseased bushes. In my last Report I wrote: "This year, 1913, the state of things is even more unsatisfactory than in 1912. The total affected acreage is considerably more, and the proportion where the autumn 'tipping' of affected shoots as directed by the Board's Orders has *not* been carried out is considerably larger, for in January, 1913, no less than 1,586 acres (or nearly

one half of the total affected area) which should have been pruned by October 31st, 1912, were still unfinished. . . . Assuming that the measures officially decided upon are satisfactory, the failure to enforce them during the past few years has made the work in connection with the Board's 'American Gooseberry Mildew Orders' a waste of public money.' "

It should be noted, too, that at this time, *i.e.*, early in 1913, some fifteen or twenty summonses were on the point of being served on some of the largest farmers for not carrying out the " tipping " in winter in a satisfactory manner.

The Maidstone Farmers' Club then arranged a meeting of delegates at the Board of Agriculture, and an astonishing thing happened. Although for several years past the Board have been insisting upon the absolute necessity of the winter " tipping " being strictly carried out, and had themselves helped to secure convictions against farmers in other counties who had not complied with the requirements of the " Orders," the Board's representative at this meeting (at which no Government scientific advisor was present) suddenly abandoned the whole position, exempted from all penalties those farmers in Kent who had not carried out the provisions of the Order, and granted their wish that they might substitute spraying for " tipping," on their signing an agreement with the Board.

In June, 1913, the Maidstone Farmers' Club were able to send to their members the following letter :

" It has been strongly felt by the Members of this Club and Chamber that tipping as a preventive of Gooseberry Mildew is a very disastrous and unprofitable method, rendering the bushes in a short time almost useless.

" As an alternative the Board of Agriculture, upon representations being made to it by this Club and Chamber, and after several Conferences with its Delegates upon the subject, has consented to allow Growers in Kent to substitute spraying for tipping as a preventive of Gooseberry Mildew experimentally during the years 1913 and 1914, upon their signing and forwarding the enclosed agreement to the Board at the address given therein.

" The Board has shown itself to be extremely anxious to co-operate with Growers in every way in order to discover

the best means of safeguarding gardens from the ravages of this disease, and it is hoped therefore that many Growers will take advantage of the alternative offered them under the Agreement, in order that the experiment may be as comprehensive as possible, and that it may lead to the adoption of a safe and economic means of combating the disease."

The Agreement mentioned in this letter is as follows :

I,..... of.....
in the County of Kent, hereby undertake to keep a careful observation either in person or through the agency of a trustworthy foreman, on all the gooseberry and currant bushes on land in my occupation, and to report forthwith the appearance of the summer-stage of American Gooseberry Mildew on any of the said bushes to the Head of the Horticulture Branch of the Board of Agriculture and Fisheries, Craven House, Northumberland Avenue, London, W.C. I also undertake to spray with a suitable fungicide approved by an Inspector of the Board or the Local Authority, every garden in which such disease appears, not less than four times if it appears in April, three times if it appears in May or before June 21st, twice if it appears after June 21st, each spraying to be conducted in a thorough manner and to the satisfaction of an Inspector.

I will keep a true and complete record of every spraying of all my gooseberry and currant bushes, whether carried out before the disease appears or after, showing the actual date of such spraying, the materials used, the acreage sprayed, the time taken, and the number of men employed, and all the information shall be shown to any Inspector of the Board or the Local Authority at any reasonable time, and full facilities given him for making a copy of the entries. I undertake to notify the Head of the Horticultural Branch as far as possible of the actual date when I propose to spray any garden in which disease has appeared.

I undertake to destroy by fire or other suitable means any diseased fruit as soon as possible after it has been attached, and to remove and destroy on or before October 31st each year, all diseased suckers.

I undertake to carry out all these requirements carefully and conscientiously during the years 1913 and 1914, and to give the Board of Agriculture and Fisheries and the Local Authority of Kent and their respective Inspectors every information and assistance in my power that will lead to the discovery and eradication of the aforesaid disease, provided that I shall not be required to prune, tip, or otherwise cut any gooseberry or currant bushes growing on land in my occupation during the years 1913 and 1914, and I understand that this provision shall not hold good if I fail to carry out any material part of this undertaking.

A number of farmers in Kent signed the above agreement, but as could have been predicted by anyone familiar with all the circumstances, the stipulated conditions are not being carried out, and the growers are finding that the mildew cannot be dealt with by spraying alone.

In October the Kent County Council took the not unexpected step of declining to appoint any longer County Inspectors to carry out the Board of Agriculture's American Gooseberry Mildew Orders. As far back as 1910, the Committee of the Kent County Council reported as follows: "The Reports of the Inspectors with regard to the disease are very discouraging. The re-appearance of mildew in those plantations in which it was supposed to have been eradicated by the vigorous measures of pruning and spraying which were adopted is an especially discouraging fact, which raises a doubt whether these remedies will ever be really effective in stamping out the disease. Unless the remedies adopted are such as will be effective, whatever the weather may be, the question arises whether the money which is being spent in the enforcement of these Orders is not being wasted. For three years the Council's Inspectors have been carrying out with zeal and care the requirements of the Board of Agriculture, with the disappointing result that the disease now affects a much larger area than it did in 1908."

In 1910 the affected acreage in Kent was 2,852 acres; in 1913 it was no less than 3,593 acres.

The Inspector's Reports, presented in October, 1913, showed the amount and intensity of disease in each district as follows. With regard to the intensity of disease, "*bad*" signifies that above 40 per cent. of the bushes were affected; "*general*," between 40 and 15 per cent. affected; "*slight*," less than 15 per cent. affected; and "*few*," from 1 to 10 bushes affected.

Swanley District:—

The disease first appeared on May 7th, and the following cases were recorded in each month:—

May	.. ..	20 cases.
June	.. ..	132 ,,
July	.. ..	174 ,,
August	.. ..	130 ,,
September	.. ..	11 ,,

giving a total of 467 infected plantations, of which 77 (affecting 112 acres) were new cases.

The following table gives the intensity of the disease :—

Year.	Bad.	General.	Slight.	Few.	Total.
1908	393	231	378	232	1234 acres.
1909	122	84	250	431	887 ,,
1910	279½	208½	635	263½	1387 ,,
1911	162	63	403	445	1073 ,,
1912	228	200	335	534	1297 ,,
1913	131½	260	384	502½	1277 ,,

Maidstone District :—

The disease first appeared on April 14th, and the following cases were recorded in each month :—

April	.. ..	1 case.
May	.. ..	27 cases.
June	.. ..	123 ,,
July	.. ..	264 ,,
August	.. ..	198 ,,
September	.. ..	81 ,,
October	.. ..	5 ,,

giving a total of 699 infected plantations.

The following table gives the intensity of disease in each year :—

Year.	Bad.	General.	Slight.	Few.	Total.
1908	225	149	330	316	920 acres.
1909	130	65	148	145	488 ,,
1910	222	247	462	295	1226 ,,
1911	171	223	474	259	1127 ,,
1912	152	394	529	397	1472 ,,
1913	130	390	645	717	1882 ,,

Of the total infected (1,882 acres), newly infected plantations account for 380 acres.

Sandwich District :—

The disease first appeared on April 19th, and the following cases were recorded in each month :—

April	.. ..	11 cases.
May	.. ..	50 ,,
June	.. ..	133 ,,
July	.. ..	83 ,,
August	.. ..	61 ,,
September	.. ..	38 ,,
October	.. ..	10 ,,

giving a total of 386 infected plantations, of which 49 (affecting 49 acres) were not known to be diseased last year.

The following table gives the intensity of disease in each year :—

Year.	Bad.	General.	Slight.	Few.	Total.
1909	—	5½	4	2½	12 acres.
1910	9½	65½	167¼	7¼	249½ ,,
1911	25	39½	137¼	94¾	296½ ,,
1912	92¼	114½	100	100¼	407 ,,
1913	147¾	135½	117	84¼	484 ,,

As the result of the unsatisfactory nature of the above Report, showing as it did an enormous increase in the area affected, after the carrying out for six years of the Board of Agriculture's " American Gooseberry Mildew Orders," the Kent County Council informed the Board in October that they refused to appoint for the future any local Inspector to enforce the Orders in Kent.

The Clerk to the County Council received in reply the following communication from the Assistant Secretary of the Board of Agriculture :—

" I have laid before the Board of Agriculture and Fisheries your letter of the 21st ult., in which you inform them that your Executive Committee have decided not to appoint any Inspectors, whereby your Local Authority will be without

the services of an Inspector to enforce the Orders issued under the Destructive Insects and Pests Acts. In reply, the Board desire me to make the following observations which I am to request you to be so good as to lay before the County Council at their next meeting, when the question raised by the Committee's decision is discussed.

" The Board are aware that the opinion has been expressed by a certain section among the fruit-growers that no remedy or effectual treatment for American Gooseberry Mildew is known, and that it would be better to leave each individual grower to deal with the disease in his own garden than to attempt to carry out the present methods. I am to suggest that if it is the case that your Committee have been influenced by this opinion the following observations should be considered by your Council before giving it their support.

" It is obvious that if it has been found difficult to cope with the Mildew by regular and concerted action, it will be more difficult to control the disease when the action is unsystematic and disorganized, for it is not to be supposed that occupiers of infected premises will be more active in suppressing disease when left to their own devices than when subject to the pressure of an Inspector. It is true that several Kentish growers have attempted to deal with the cases on their own plantations by various methods, but their efforts have generally been rendered of no effect by the neglect of their neighbours to adopt proper precautions at the same time ; and so far as the Board are aware there has been no serious attempt on the part of the fruit-growers of Kent as a whole to free their County from the infection. The Board desire me to point out to your Council what an unfortunate contrast their County affords as compared with the fruit-growing district of Worcestershire. Disease was found to be widespread and serious in that County before it was known in Kent, and it was at one time thought that it was hopeless to save the Gooseberry growing industry there. The usual disinclination to adopt prompt measures was experienced and even organized resistance was shown to the Board's Order. The Local Authority for Worcestershire, however, conceived it to be their duty to enforce the Board's Order strictly, and legal proceedings were taken against a number of

offenders. Convictions were obtained in due course, these resulted in a readier compliance with the requirements of the Board's Order, and since that date the disease has generally decreased in Worcestershire, even in years when owing to unfavourable climatic conditions it has increased elsewhere. There is every reason to believe that soon American Gooseberry Mildew will in Worcestershire be reduced to very small dimensions, and the industry in that County freed from an expense and embarrassment which has in the past seriously hampered them in the competition with other districts, so that the acreage under gooseberrries there will be increased. The enclosed tabular statement shows the position in Worcestershire and Kent respectively. The same experience holds good in all other places where the procedure contemplated by the Board's Order is carried out, and success has been obtained in proportion to the strictness with which it is enforced. Your Committee on the other hand, have in no single case prosecuted any offenders, although several cases have been brought to their notice by Mr. Vinson and by the Board, which might properly have been made the subject of legal proceedings.

"The Board think that your Committee in deciding on the course of action which they recommend, have unwittingly taken a step that is not in the best interests of fruit growing in Kent, and if their decision is not re-considered, the industry will suffer a blow from which it will take many years to recover. In view of the unmistakeable evidence of other districts in favour of a strict compliance with the provisions of the Order, the Board are unwilling to believe that the Kent County Council will lend any countenance to the proposition that American Gooseberry Mildew is a disease, the control of which may be left to the unaided energies of fruit growers, and they trust that it will be decided to continue the administration of the Destructive Insects and Pests Acts, and to enforce its compliance with the Orders by legal proceedings where necessary.

"The matter is, moreover, of more than local interest. Many countries have imposed restrictions on the importation of plants from England, and a large and valuable trade is in danger of being injured unless the infectious diseases of

plants are controlled by proper precautions and adequate inspection. The Board are unwilling to think that your Council would intentionally jeopardize the trade of the country by neglecting to carry out their statutory duties, and I am therefore directed by the Board to invite the special consideration of your Local Authority to this aspect of the question."

AMERICAN GOOSEBERRY MILDEW.

Year.	KENT.		WORCESTER.	
	Number of Outbreaks.	No. of outbreaks where the fruit was reported to be attacked.	Number of Outbreaks.	No. of outbreaks where the fruit was reported to be attacked.
1909-10	435	13	220	24
1910-11	1127	29	294	10
1911-12	966	108	159	38
1912-13	1351	328	214	31
1913-14 (to 30th Sept. 1913.)	1538	370	143	35

The Kent County Council remained unconvinced by the arguments put forward by the Board as above, and persisted in their refusal to carry out any longer by their own Inspectors the American Gooseberry Mildew Orders. The last Report, presented on January 12th, 1914, by the Local Inspector, was as follows :—

"*Swanley District :—*

Since my Report in October, it has only been possible to inspect but very few plantations in this district, but where growers have applied for Licences for the removal of bushes I have taken the opportunity of inspecting a number of plantations.

The infected acreage (as far as it is known) therefore remains the same as given in my October report, viz. :—

Infected acreage	1,277 acres	=466 Plantations.
Passed as satisfactory ..	20 ,,	= 16 ,,
Leaving to be passed as satisfactory	1,257 ,,	=450 ,,

There are, however, a number of scheduled plantations in this district that have not been inspected during the past season.

Sandwich District :—

Infected acreage	476 acres	=382 Plantations.
Passed as satisfactory ..	$28\frac{3}{4}$,,	= 36 ,,
Leaving to be passed as satisfactory	$447\frac{1}{4}$,,	=346 ,,

There have been 9 acres grubbed in this district.

Growers are still applying for Licences for the removal of bushes in this district.

Maidstone District :—

Since my report in October there have been 23 cases of disease found.

Infected acreage	1,902 acres	=719 Plantations.
Passed as satisfactory ..	$378\frac{1}{2}$,,	=148 ,,
Leaving to be passed as satisfactory	$1,524\frac{1}{2}$,,	=571 ,,

There have also been about 30 acres grubbed in this district.

A great deal of my time has been occupied in inspecting nursery stock for the issuing of Licences, one case has occurred where a grower sent a consignment of bushes to Northumberland, which were slightly diseased."

On the refusal of the Kent County Council to administer the Orders, the Board of Agriculture decided to appoint a staff of "Local" Inspectors for Kent and other Counties. The American Gooseberry Orders, therefore, still remain in force in Kent, just as before, although they are no longer in any way under the control of the County Council.

Reviewing the course of events during the past year, it must be pointed out that the action of the Board in condoning the refusal of certain growers to "tip," and allowing them to substitute spraying, must inevitably make the carrying out of the Order of much greater difficulty in the future.

The absence of a decisive official plan, based on authoritative scientific advice, which has lately characterized the

proceedings, must be attributed to the fact that the Board of Agriculture, in dealing with this mildew, are still without the advice or guidance of any mycologist conversant with the practical details. There is now an official entomologist supplying such assistance in the case of the insect pests which are being dealt with by legislative measures, but there is no mycologist. With the recent discovery of new and important facts in the life history of the American Gooseberry Mildew, (see below, p. 46 and p. 53), which may be of considerable importance in the practical control of the disease, the need for an official mycologist to give advice as to the best State measures to be adopted against the mildew, becomes more and more imperative.

The results of the spraying experiments carried out last year in Kent are given below at p. 17. With the heavier infestation of plantations that is occurring annually, it is clear that an earlier appearance of the mildew than previously must be expected, especially on the berries.

This year I received examples of the "summer-stage" from a plantation in East Kent, on April 6th; and the Board of Agriculture have reported a similar case in a plantation in Cambridgeshire, on the same date.

SPRAYING EXPERIMENTS AGAINST THE AMERICAN MILDEW.

(*Sphaerotheca mors-uvae*).

By E. S. Salmon.

In previous numbers of this *Journal* I have given the results of spraying experiments against the American Gooseberry mildew, which have been carried out during past seasons either at Wye College, or on fruit farms in Kent. In the present article the spraying experiments which were carried out during 1913 on farms at three centres in Kent are described. Further, some new or little-known facts—likely to prove of practical importance—concerning the life history of the American Gooseberry-mildew are here recorded.

1.—*Spraying Experiments.*

The spraying experiments in 1913 had two main objects ; firstly, to continue the work of ascertaining at what strength and to what extent lime-sulphur can be used on the various commercial varieties of Gooseberries without causing injury ; and secondly, to compare the fungicidal action, against the mildew, of lime-sulphur and the "liver-of-sulphur" solution. The bushes used, situated in large commercial plantations on fruit farms at the three centres, Rodmersham, Boughton-under-Blean, and Mereworth, were freely offered by farmers for experimentation in any direction. In order to ensure thorough and uniform sprayings, the work of mixing and applying the various washes used was done by Mr. R. G. Hatton and myself, Mr. R. G. Hatton (now of the Horticultural Staff of Wye College) doing all the actual spraying, as well as assisting in making observations. It has been due to Mr. Hatton's energy and strength that a very large number of bushes were able to be sprayed experimentally. The Vermorel "Eclair étamé" knapsack sprayer was used, with a nozzle giving a very fine "misty" spray.

The sprayings will be described under the different centres and the name of the variety of Gooseberry.

CENTRE: RODMERSHAM:

PLOT 1.—YELLOW ROUGH (GOLDEN DROP).

The bushes were eight years old, in a plantation shaded by mature fruit trees.

May 2nd.—(1) 6 bushes sprayed with lime-sulphur, 1.01 sp. gr.
(2) 5 ,, ,, ,, ,, 1.005 sp. gr.
(3) 25 ,, ,, ,, iron-sulphide (Oregon formula)*

On *May 13th* no appreciable injury was visible, but there were slight indications of a leaf-fall beginning on the iron-sulphide plot; these bushes were, therefore, not sprayed again.

May 13th.—(1) As before.
(2) ,,
(4) 8 bushes sprayed with lime-sulphur 1.01 sp. gr.
(5) 9 ,, ,, ,, ,, 1.005 sp. gr.
(6) 10 ,, ,, ,, "liver-of-sulphur" solution, 1 oz. to 3 gall. water.

On May 26th the following injury was observed:—

(1) and (2). A very severe leaf-fall had taken place, and there was a characteristic odour of decaying vegetation from the sprayed leaves still remaining on the bushes. The amount of injury done was sufficient to preclude the use of lime-sulphur. (3) The bushes showed a serious leaf-fall; from many of them came the characteristic sickly-sweet or almost pungent smell of leaves injured and slowly dying as the result of the spraying. In view of the fact that the iron-sulphide spray is stated to be quite harmless to the foliage of the apple and rose, the doubt arose whether the wash used (although made strictly according to the formula) had been washed absolutely free of lime-sulphur (see footnote). To test this point, sprayings were now made with the iron-sulphide wash, proved by chemical tests to be absolutely free from lime-sulphur (see below, *May 26th*, (9) and (10)). (4) The bushes now showed that a marked leaf-fall had been caused. (This had not taken place, it may be noted, by May 20th.) (5) The bushes showed a leaf-fall just commencing. (6) No leaf-fall had taken place, but there was a more or less distinct yellowing of the older leaves, caused by the action of the spray. Since, on the plots (1), (2), (4) and (5), the same serious injury was being caused by the lime-sulphur spray

* This wash was made on the following formula, given by Prof. P. J. O'Gara, in his leaflet, "Lime-Sulphur," (Rogue River Valley, Medford, Oregon. 1911). "Iron-sulphate. 1lb. lime-sulphur (32 degrees Beaume test) 1 quart, water 10 gallons. Dissolve the iron-sulphate in about 5 gallons of water and add the quart of lime-sulphur, stirring well. Let the black precipitate settle for a few hours and pour off the liquid, keeping the precipitate. Then add 5 gallons of water, stir thoroughly and let settle again. Pour off the liquid as before. This process is called washing, and is necessary in order to get rid of the lime-sulphur, which would burn tender foliage. Repeat the washing until the water is no longer yellow. The black 'muck' should be diluted to 10 gallons and sprayed with good agitation. . . . This is the standard [summer] spray for apple and rose mildew for this district." This spray did not spread well, though the leaves of the bushes became fairly well covered with the large blotches.

as had been observed in previous seasons, it was decided to discontinue the use of this spray.

May 26th.—(6) As before.
(7) 8 bushes sprayed with "liver-of-sulphur" solution, 1 oz. to 3 gall. water.
(8) 8 bushes sprayed with "liver-of-sulphur" solution, 2 ozs. to 3 gall. water.
(9) 8 bushes sprayed with iron-sulphide.
(10) 8 „ „ „ „ half-strength.

On *June 6th* all the sprayed bushes showed so severe a defoliation that it was useless to continue using any of the washes. The chemically tested iron sulphide (9) and (10), had produced as severe an injury as that originally used. (3) All the bushes where "liver-of-sulphur" had been used were by now equally damaged.

At this date, also, it was apparent that the sprayings had not kept off the mildew from the fruit of the bushes in many of the plots; a number of berries were severely affected, more particularly in the iron-sulphide plots.

The high degree of susceptibility which is shown by *Yellow Rough* to injury from the effects of sulphur washes became apparent under the following circumstances. A plantation of *May Duke* was sprayed with lime-sulphur; a short time afterwards it was observed that some bushes of *Yellow Rough* which adjoined the sprayed *May Dukes*, although they had been untouched by the spray, had dropped a considerable number of their leaves. This injury extended to about five rows of the *Yellow Rough*. It seemed clear that in this case the gas (either sulphuretted hydrogen or sulphur dioxide) which is given off from the lime-sulphur wash when exposed to the air, was responsible for this leaf-fall. To ascertain whether this really was the case, some lime-sulphur was sprayed on to the soil surrounding some bushes of *Yellow Rough*, care being taken that none of the spray touched the bushes. After a few days a considerable leaf-fall resulted.

The Kent County Council Inspectors have informed me that "flowers of sulphur" dusted over bushes of *Yellow Rough* causes a severe defoliation.

All the experiments show clearly that it is unsafe to use sulphur in any form on *Yellow Rough*, as severe defoliation results. The same is the case when the iron-sulphide wash is used.

PLOT 2.—FREEDOM.

The bushes were eight years old, and partly shaded under fruit trees.

May 2nd.—(1) 6 bushes sprayed with lime-sulphur, 1.01 sp. gr.
(2) 6 „ „ „ „ „ 1.005 sp. gr.

May 13th.—(1) As before.
(2) „
(3) 10 bushes sprayed with lime-sulphur, 1.01 sp. gr.

May 26th.—(1) As before.
(2) ,,
(4) 8 bushes sprayed with lime-sulphur, 1.01 sp. gr.

On *June 6th* the bushes in (1) and (2) which had been sprayed three times with lime-sulphur, showed a marked leaf-fall. No leaf-fall or other injury appeared on the bushes (3) sprayed once with lime-sulphur on *May 13th;* while a slight, but not serious, leaf-fall occurred on the bushes (4) sprayed once with the same wash on *May 26th.*

It would appear that *Freedom* may safely be sprayed with lime-sulphur at "full strength" once or twice in May or earlier, but more repeated applications or spraying later in the season will cause a certain amount of leaf-fall.

PLOT 3.—HOWARD'S LANCER.

The bushes were ten years old, and situated in the open.

May 2nd.—(1) 5 bushes sprayed with lime-sulphur, 1.01 sp. gr.
May 13th.—(1) As before.
June 12th.—(1) ,,

No injury resulted at any time. It seems safe to conclude that *Howard's Lancer* may safely be sprayed three times successively with "full strength" lime-sulphur during May and June.

PLOT 4.—MAY DUKE.

The bushes were twelve years old, and growing in an open position.

May 13th.—(1) 11 bushes were sprayed with lime-sulphur, 1.01 sp. gr.
(2) 6 bushes ,, ,, ,, "liver-of-sulphur" solution, 1 oz. to 3 gall. water.
May 26th.—(1) As before.
(2) ,,
June 6th.—(1) As before.
(2) ,,
June 12th.—(1) As before.
(2) ,,
June 23rd.—(1) As before.
(2) ,,

Beyond the falling of a few leaves from the bushes sprayed with "liver-of-sulphur," no injury resulted. It can be concluded, therefore, that *May Duke* may safely be sprayed five times successively, during May and June, with either lime-sulphur or "liver-of-sulphur" solution.

PLOT 5.—GUNNER'S SEEDLING.

The bushes were eight years old, and partly shaded under fruit trees.

May 2nd.—(1) 14 bushes sprayed with lime-sulphur, 1.01 sp. gr.
(2) 10 ,, ,, ,, ,, 1.005 sp. gr.

May 13th.—(1), (2), (3) 50 bushes (including (1) and (2)) were sprayed with lime-sulphur, 1.01 sp. gr.

(4) 11 bushes were sprayed with "liver-of-sulphur" solution, 1 oz. to 3 gall. water.

May 26th.—(1), (2), (3) As before (a light spraying only, to cover the new shoots).

(4) As before.

June 6th.—(5) 25 bushes sprayed with lime-sulphur, 1.01 sp. gr.

(6) 11 bushes sprayed with liver-of-sulphur solution, 2 oz. to 3 gall. water.

June 12th.—(1), (2), (3) As before.

(4) ,,

No injury whatever resulted from any of the sprayings. *Gunner's Seedling* may safely be sprayed four times successively during May and June with "full-strength" lime-sulphur.

PLOT 6.—COUSIN'S SEEDLING (*Sandwich Yellow*).

The bushes in one part of the plantation were eight years old (called "old" below), and more or less shaded under fruit trees; in the other part they were four to six years old (called "young" below), and situated in the open.

May 2nd.—(1) 12 "old" bushes sprayed with lime-sulphur 1.01 sp. gr.

(2) 10 ,, ,, ,, ,, ,, 1.005 sp. gr.

(3) 20 "young" ,, ,, ,, 1.01 sp. gr.

On *May 13th* no injury was observable.

May 13th.—(1), (2), (4) 50 "old" bushes (which included (1) and (2), sprayed with lime-sulphur, 1.01 sp. gr.

(3), (5) 53 "young" bushes (which included (3)), sprayed with lime-sulphur, 1.01 sp. gr.

(6) 10 "old" bushes sprayed with "liver of sulphur" solution, 1 oz. to 3 gall. water.

(7) 20 "young" bushes, sprayed with "liver of sulphur" solution, 1 oz. to 3 gall. water.

On *May 26th* no injury was observable on the "old" bushes; in the case of the "young" bushes sprayed with lime-sulphur (3), (5) the leaves showed a slight but distinct scorching of many of the leaves, which were brown at the tips and edges; no leaf-fall resulted and the injury done was not serious and of no practical importance. (The same scorching effect was noticeable on the adjoining part of the plantation—consisting of bushes of the same variety and age—where spraying had been done with a power sprayer, using lime-sulphur 1.01 sp. gr.).

May 26th.—(3), (5) As before.

(6) ,,

(7) ,,

(8) 10 "old" bushes sprayed with "liver of sulphur" solution, 1 oz. to 3 gall. water.

(9) 7 "old" bushes sprayed with "liver of sulphur" solution, 2 oz. to 3 gall. water.

June 6th.—(10) 15 "old" bushes sprayed with "liver of sulphur" solution, 2 oz. to 3 gall. water.

(11) 37 "old bushes" sprayed with lime-sulphur, 1.01 sp. gr.

June 12th.—(1), (2), (4), As before.
(3), (5) ,,
(6) ,,
(8) ,,
(9) ,,
(10) ,,

June 23rd.—(1) (2) (4) As before
(3) (5) ,,
(10) ,,

July 12th.—(1), (2), (4) As before
(3), (5) ,,

The results of the sprayings as regards injury may first be noted, and then, secondly, the effect of the sprayings in dealing with an outbreak of the mildew that occurred in this plantation. The experiments demonstrated that lime-sulphur at "full-strength" can be used with perfect safety on *Cousin's Seedling*—a variety not hitherto experimented with. Successive sprayings, repeated five times, on "old" bushes, and six times on "young" bushes, from May to July, caused no appreciable injury to the leaves or shoots. This is a fact likely to prove of considerable practical importance in the future treatments against mildew of this very valuable late dessert gooseberry. The "liver-of-sulphur" solution, at 1 oz. to 3 gall. water, caused no appreciable amount of scorching, and no leaf-fall; but the same solution at the rate of 2 ozs. to 3 gall. water, even when applied in cool weather, caused an amount of injury which clearly indicated that the danger-point was reached. As, however, the "liver-of-sulphur" solution showed itself under the conditions to be quite ineffectual in stopping the spread of the mildew, the point is of less practical importance.

On *May 26th* the outbreak of mildew first started in the plantation. On that day the mildew was found in the "powdery" summer-stage, curling the young leaves of some shoots growing from four bushes of *Cousin's Seedling*, which had been cut down to the ground in the summer of 1912, because they were at that time virulently attacked by the mildew. In one case, even at this early date—May 26th—the spawn (*mycelium*) of the mildew on the surface of one of the shoots was turning brown, *i.e.*, beginning to form the "winter-stage." On the discovery of the outbreak, the four bushes were very heavily sprayed with lime-sulphur, 1.01 sp. gr. On *June 6th* all the original patches of mildew on the four bushes were seen to be stopped or killed, and no fresh infections on these bushes were to be found. The spray had slightly scorched the tips of the young leaves, but no appreciable injury was caused. By this day (*June 6th*) the mildew had appeared on nineteen more bushes of Cousin's Seedling. On these bushes the mildew was in vigorous white powdery patches, both on the berries and on the leaves of the shoots (which were curling under the attack), and

also, it had developed in many cases the brown winter-stage both on the berries and on the surface of the shoots. The infection of these nineteen bushes had certainly taken place between *May 26th* and *June 6th*. The general condition of these infected bushes and the spray given them on *June 6th* were as follows :

Bush 5.—Severe attack ; summer- and winter-stage on tips of most shoots.
,, 6.—Slight attack, just starting ; summer-stage only on few tips.
,, 7.—Severe ; summer-stage on most tips.
,, 8.—Slight ; summer-stage on few tips.
,, 9.—Severe ; summer- and winter-stage on many tips.
,, 10.—Slight ; summer-stage just beginning.
,, 11.—Slight ; summer-stage just beginning.

Bushes 5 to 11 were given a heavy spraying (the bushes being drenched) with "liver of sulphur" solution, 2-oz. to 3 galls. water.

,, 12.—Moderate attack ; summer- and winter-stages on several shoots.
,, 13.—Slight attack ; summer-stage just beginning.
,, 14.—Slight attack ; summer-stage just beginning.
,, 15.—Severe attack ; most tips affected with big patches of summer-stage.
,, 16.—Severe attack ; most tips affected with big patches of summer-stage.
,, 17.—Slight attack ; summer-stage only.
,, 18.—Severe attack ; a little winter-stage as well as summer-stage on most of the shoots.
,, 19.—Slight attack ; summer-stage on shoots and a number of berries.
,, 20.—Slight attack ; summer-stage on shoots and a number of berries.
,, 21.—Slight attack ; summer-stage on shoots only.
,, 22.—Slight attack ; summer-stage on shoots only.
,, 23.—Slight attack ; summer-stage on shoots only.

On *June 12th* the seven bushes (Nos. 5 to 11) which had been sprayed heavily on *June 6th* with "liver of sulphur" solution were examined, and it was found that *the spread of the mildew had not been checked on them*,—the disease being quite as bad or even worse, with numerous white, powdery patches of the summer-stage, and extended patches of the brown winter-stage. The twelve bushes (Nos. 12 to 23) which had been sprayed with lime-sulphur, were in a much healthier condition ; there were now no powdery patches of the summer-stage, though patches of the winter-stage were still to be seen, and it was clear that the spread of the disease was greatly checked. At this date the seven bushes (Nos. 5 to 11) were again sprayed with the "liver of sulphur" solution ; the lime-sulphured bushes (Nos. 12 to 23), being still well covered, did not at this time receive another spraying.

On *June 23rd* another examination was made of the mildewed bushes in this plantation. Taking first the four bushes which had

been cut down in 1912, the shoots from these had by now produced about six inches of fresh growth; in most cases these had become attacked by mildew. The condition of the bushes was as follows: bush (1), a good deal of summer-stage on the young shoots; (2) and (3), tips badly infested with both the white "summer-stage" and the brown "winter-stage"; (4) no fresh infections. These bushes were now sprayed again with lime-sulphur.

With regard to the bushes sprayed with the "liver of sulphur" solution, their condition was as follows:

Bush 5.—*A mass of disease;* the spawn (*mycelium*) had developed extensively, and now covered the tips of the greater number of the shoots with continuous brown patches, half inch to three inches long; the fruit, too, was much attacked, about 75 per cent. of the berries being more or less completely enveloped in the brown winter-stage.

Bush 6.—Mildew still present in both summer- and winter-stages on the tips of most shoots.

Bush 7 and 8.—Tips of shoots with abundant powdery summer-stage,—disease in very infectious stage and obviously on the increase.

Bush 9.—Disease severe; on shoots and berries in summer- and winter-stages.

Bush 10 and 11.—Most of the tips of the shoots smothered with the summer-stage, and about 50 per cent. of the berries with large patches of the winter-stage.

It was perfectly clear that under the conditions prevailing the "liver of sulphur" solution was powerless to check in any way the spread of the mildew. The facts are as follows: The bushes had been kept under careful observation through May and June, and it is certain that no mildew was present until *June 6th*, when a very few spots of the white summer-stage were found. All the bushes were immediately drenched with "liver of sulphur" solution at the strength of two ounces to three gallons of water,—which was clearly the strongest solution possible, since at this strength the tips of the youngest shoots were turned brown and killed, and also the edges of the young leaves were scorched and shrivelled up. Another similar drenching with the same wash was given on *June 12th*, less than a week after; yet the disease was not appreciably checked in any way, many of the bushes on *June 23rd* being literally smothered with disease on shoots and berries. In the case of some of the bushes, notably bushes 5, 10 and 11, the fact that all or nearly all the berries on the lower branches became so rapidly and severely attacked strongly suggests that at the time infections were occurring plentifully from "winter-spores" (*ascospores*) arising from fruit-bodies (*perithecia*) which had wintered over, on or in the soil under or round the bushes.

The bushes which had received lime-sulphur were found to be in the following condition:—

Bush 12.—Small patches of the winter-stage on a few shoots (probably at the places where it existed at the time of spraying); two tips with powdery summer-stage; disease not severe.

Bush 13.—A trace only of mildew on a very few tips.

Bush 14.—A few tips with the mildew in the summer- and winter-stages; a good number (about 25 per cent.) of the berries more or less completely enveloped in the brown winter-stage. *In many cases these berries had been well sprayed with the lime-sulphur, yet they had become more or less covered with the winter-stage. The spawn (mycelium) of the winter-stage of the mildew could be seen growing and extending over the "blotches" or spots of the dried lime-sulphur.*

Bush 15, 16, and 17.—From 10 to 25 per cent. of the berries affected with the winter-stage; only a few tips showing the mildew (in summer-stage).

Bush 18.—Tips of shoots free from mildew; a little winter-stage on a few berries.

Bush 19.—Two tips apparently just infected,—white and powdery.

Bush 20.—Shoots all healthy.

Bush 21.—A mere trace of the disease.

Bush 22.—Many (about 40 per cent.) of the berries and also of the shoots with patches of the winter-stage; a few tips showing the summer-stage.

Bush 23.—Fresh infections on many of the tips; patches of the winter stage on the older parts of several shoots.

Although these bushes, which had been sprayed once with lime-sulphur, had certainly considerably less mildew on them than those bushes (Nos. 5 to 11) which had been sprayed twice with the "liver of sulphur" solution, it was clear that the lime-sulphur wash had had no deterrent effect on the growth of the *mycelium* of the winter-stage. Further, either the spraying on *June 6th* had not killed all the summer-stage present, or, more probably, the young growth of the bushes had become re-infected by *air-borne spores* in the interval between *June 6th* and *June 23rd*. As in the case of the bushes, noted above, there were indications, *e.g.*, with respect to bushes 14, 15, 16, 17 and 22, that the berries had all been heavily infected about the same time, very possibly from winter-spores (*ascospores*) arising from the soil; in which case spraying would be of little or no use.

It may be noted, further, that the fifteen bushes (see p. 22 (10)), which had been sprayed heavily with "liver-of-sulphur" solution on *June 6th*, *June 12th*, and *June 23rd*, were on *July 12th* smothered with mildew at the ends of the shoots.

In 1912 many of these bushes of *Cousin's Seedling* suffered from a severe attack of mildew, and the berries became very badly diseased. The diseased berries were not removed until August, when the crop was ripe, by which time it is probable that considerable numbers of fruit-bodies (*perithecia*) had fallen to the ground (see below, p. 38). The sudden and severe attack on the berries in 1913 (noted above) may perhaps be attributable to winter-spores arising from the ground in June, 1913, in consequence of the infestation of the soil in August, 1912.

Cousin's Seedling appears to be specially liable to severe attacks of the mildew, both on the shoots and on the berries. Owing to its habit of growth, *viz.*, the horizontal branches keeping low near the ground, the bush is difficult to spray, unless specially pruned to encourage an upward growth of the branches. In view of the great damage done by the mildew to this variety, such a system of pruning should always be adopted. When the berries are attacked early, *the entire crop may be destroyed.* The young berries often become completely infested all round with the brown scurf-like spawn (*mycelium*) and so are prevented from growing out (see photograph of the upper berries in Plate 1).

In a one-acre plantation of *Cousin's Seedling* in East Kent, which I visited last August, there was scarcely one berry to be found which was not diseased; the great majority of the berries over the whole plantation had been prevented by the mildew from growing to more than a quarter of their proper size (see Plate I.). Not a berry was picked for market off the whole piece. It is extremely important, for the reason given below (p. 38) that all diseased berries of *Cousin's Seedling* and other late varieties, are picked and destroyed before the mildew has developed the brown winter-stage on them.

Plot 7.—Berry's Early.—The bushes were about ten years old, and shaded under mature fruit-trees.

May 13th.—(1) Six bushes sprayed with lime-sulphur, 1.01 sp. gr.
(2) Six bushes sprayed with lime-sulphur, 1.005 sp. gr.
(3) Eight bushes sprayed with "liver-of-sulphur" solution, 1 oz. to 3 gallons of water.

May 26th. (1) As before.
(2) ,,
(3) ,,
(4) Ten bushes sprayed with lime-sulphur, 1.01 sp. gr.
(5) Seven bushes sprayed with lime-sulphur, 1.005 sp. gr.
(6) Ten bushes sprayed with "liver-of-sulphur" solution, 1 oz. to 3 gallons water.
(7) Ten bushes sprayed with "liver-of-sulphur" solution, 2 ozs. to 3 gallons water.
(8) Seven bushes sprayed with iron-sulphide, "half-strength."

June 12th.—(1) As before.
(2) ,,
(3) ,,
(4) ,,
(5) ,,
(6) ,,
(7) ,,
(9) Four bushes sprayed with "liver-of-sulphur" solution, 1 oz. to 3 gallons water.
(10) Four bushes sprayed with "liver-of-sulphur" solution, 2 ozs. to 3 gallons water.

June 23rd.—(1) As before.
(2) ,,
(9) ,,
(10) ,,
July 12th.—(1) ,,
(2) ,,
July 28th.—(1) ,,
(2) ,,

No injury resulted in any case, even on the bushes (1) and (2), which received six thorough sprayings with lime-sulphur.

The effect of the spraying on the mildew may now be noted. By July 12th a severe attack of mildew was in evidence in the plantation (of about $1\frac{1}{2}$ acres) of Berry's Early in which Plot 7 was situated. The mildew occurred in its summer- and winter-stages practically all over the plantation, being particularly bad on the bushes adjoining the sprayed plot, some of which had practically every tip badly attacked. An examination of the sprayed bushes at this date gave the following results :—

(1) The eight bushes which had been sprayed four times with "full strength" lime-sulphur were quite free from mildew.

(2) The ten bushes sprayed four times with "half-strength" lime-sulphur showed the mildew just appearing on the tips of several shoots.

(4) and (5) These bushes sprayed twice with lime-sulphur (last spraying June 12th), were just beginning to be attacked at the tips.

(3) These bushes sprayed three times with "liver-of-sulphur" solution were very badly infected for a considerable length at the ends of most of the shoots.

(6) The ten bushes sprayed twice with the "liver-of-sulphur" solution were now all badly infected on most of the shoots.

(7) The ten bushes sprayed with the stronger solution of "liver-of-sulphur" were similarly affected.

(8) The bushes were all badly infected.

(9) and (10) The two sprayings with "liver-of-sulphur" solution on *June 12th* and *June 25th* had not protected the bushes from infection, most of the tips now showing the disease in a virulent and infectious condition.

The first interesting point was the superiority shown (as in the case of Plot 6 of *Cousin's Seedling*, p. 23), by lime-sulphur in keeping off the mildew in comparison with the "liver-of-sulphur" solutions. The second point of interest was the sudden appearance of the mildew in such virulence over so large an area ; on June 23rd there was no sign of the mildew over the whole plantation of *Berry's Early*, by *July 12th* the mildew was general over the whole piece with the exception of plots (1), (2), (4), and (5), not only in the summer-stage, but it was equally plentiful in the winter-stage. There was every indication of the

bushes having been generally infected by a profusion of "summer-spores" carried on the wind into the plantation. Could this have been anticipated, a thorough spraying with lime-sulphur on some date between June 23rd and July 12th, would have saved this particular plantation, if not entirely from the disease, at any rate from the severity of the infestation.

As the bushes (1) and (2) were, owing to the previous lime-sulphur sprayings, free or almost free from the mildew, these were sprayed again on July 12th. On July 28th the bushes in (1) and (2), which had been sprayed respectively, with lime-sulphur at "full" and "half-strength," showed traces of the mildew on the young freshly

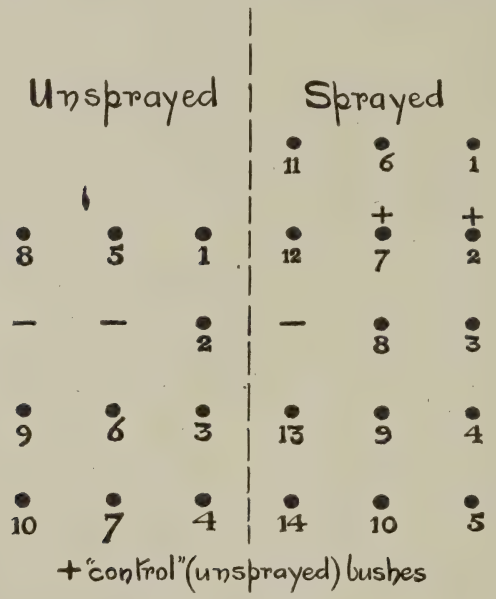

Fig 1.
Plan of sprayed and unsprayed bushes.

grown-out tips of several of the shoots. This amount of infection was practically inevitable, in view of the fact that the adjacent bushes (to which nothing was done) stood smothered with mildew in its powdery, infectious summer-stage, from July 12th onwards, so that "spores" must have been continually blown on to the sprayed bushes. Although it was known from previous observations that the spraying would not prevent the mildew already present from forming its winter-stage, lime-sulphur was applied to (1) and (2), as before, for the sixth time.

On November 24th, the final examination of the lime-sulphured bushes was made. A plan is given at Fig. 1 of the position of the bushes

(1) and (2), of the two "controls," and of the ten adjoining unsprayed bushes which were examined for comparison. These bushes were gone over in the following manner; all the shoots that showed any of the disease* were cut off, and then separated into two classes, as follows: Class 1, with more than one inch of continuously diseased shoot; Class 2, with less than one inch of continuously diseased shoot. The examination gave the following results:

SPRAYED BUSHES (1), (2) and "CONTROLS."

No. of bush in plan.	No. of shoots with *over* 1 inch continuously diseased.	No. of shoots with *under* 1 inch continously diseased.	Total No. of diseased shoots.
1	1	3	4
2 *Control*	23	37	60
3	4	14	18
4	3	7	10
5	7	11	18
6	9	7	16
7 *Control*	49	42	91
8	15	9	24
9	14	19	33
10	8	4	12
11	1	9	10
12	1	5	6
13	32	17	49
14	5	5	10

These figures show that the spraying had a considerable effect against the mildew. Taking the averages, we find that the average number of diseased shoots per bush on the twelve sprayed bushes was eighteen; while for the unsprayed "control" bushes it was seventy-five.

The good that was done by spraying is seen even more clearly by comparing the amount of disease on the bushes of the three sprayed rows with the bushes (of the same age and size) of the three adjacent unsprayed rows. The examination of these unsprayed bushes gave the following results.

* The mildew was now all in the dark brown "felted" winter-stage.

Unsprayed Bushes.

No. of bush in plan.	No. of shoots with *over* 1 inch continuously diseased.	No. of shoots with *under* 1 inch continuously diseased.	Total No. of diseased shoots.
1*	18	9	27
2	73	33	106
3	33	32	65
4	27	41	68
5	102	56	158
6	89	45	134
7	85	31	116
8	140	28	168
9	120	43	163
10	112	42	154

These figures show that the average number of diseased shoots per bush was no less than 116, of which eighty had more than one inch of continuously diseased shoot. In the case of the sprayed bushes, the average number of diseased shoots per bush was 17.5, of which 8.3 had more than one inch of continuously diseased shoot. Converting the figures as to the intensity of the disease to percentages, we have in the case of the sprayed bushes 100 shoots with over one inch continuously diseased in the 210 affected shoots, *i.e.*, 47.6 per cent., while for the unsprayed bushes the figures are 799 shoots with over one inch continuously diseased in the 1,159 affected shoots, *i.e.*, 68.9 per cent. The length of the diseased portion of the shoots that has to be removed in "tipping" is of course a point of considerable practical importance as the removal of many inches means (unless the bush is "spur" pruned) the removal of a considerable part of subsequent crops.

A point of possibly considerable practical importance may be noted here. On *July 28th* one of the bushes of *Berry's Early* in the plantation noted above, which was so badly attacked by mildew, was "tipped." The bush, which stood to the left of the "unsprayed" bushes shown in the plan on p. 28, was quite as badly affected as any of these, the tip of nearly every shoot bearing extended patches of mildew in the brown winter-stage, so that considerably over a hundred shoots had to be "tipped." On inspecting this bush in November, it was found that no fresh growth of the bush had been caused by this "tipping," and

* This was a very small bush; it had mildew on every shoot.

that in its absence there had been no fresh infection by the mildew of the bush, which now stood perfectly healthy. With large bushes of this age, then, in such a season as the past, the winter-stage of the mildew can be safely removed as early as *July 28th.*

The plantation (1½ acres) of Berry's Early was sprayed (with the exception of the bushes of Plot 7) by the farmer, as follows. On May 2nd half-an-acre was lightly sprayed with lime-sulphur at "half-strength" (1.005 sp. gr.). No injury resulted. The crop was picked on June 9th and June 10th; no sediment was then noticeable on the berries in the sprayed part. A trace of mildew was found on a very few berries,—equally in the sprayed and unsprayed parts of the plantation; very probably this early infection of the berries (no mildew occurred on the shoots at this date) was caused by winter-spores arising from the ground. On June 11th the whole plantation was sprayed with lime-sulphur, 1.005 sp. gr. No injury resulted. At the beginning of July, the plantation, for the greater part, became virulently infected, probably by air-borne summer-spores; in many cases over one hundred shoots on one bush showed badly-diseased tips (see above, p. 29). It is very doubtful if the two sprayings of lime-sulphur which were given this plantation at the dates mentioned above were of any practical use.

The weather conditions at the times of spraying at the Rodmersham centre, and the dates of the appearance of mildew in various parts of the plantation, were as follows:

May 2nd.—Bright sunshine, but not hot; showers of rain in early part of day; at the time of spraying there was no sunshine, and on most bushes a leaf here and there was still wet with rain. No mildew to be seen.

May 13th.—Cloudless sky; bright continuous sunshine, hot at times but tempered by breeze. The mildew in the summer-stage found on two bushes of *Cousin's Seedling*, in part of plantation adjoining the experimental plots. The mildewed bushes and the surrounding ones were well sprayed with lime-sulphur (1.005 sp. gr.) by the farmer on *May* 14th.

May 26th.—Continuous hot sunshine; little breeze. Mildew in very powdery and infectious summer-stage attacking virulently the shoots growing from four bushes of *Cousin's Seedling* which had been cut down for mildew in 1912. On one of the stems the spawn (*mycelium*) of the mildew was turning brown, and already beginning to form the winter-stage.

June 6th.—Bright sunshine; coolish breeze. The mildew in summer- and winter-stages appearing on the shoots and berries of unsprayed *Gunner's Seedling*; also on the berries (towards the centre of the bush) of two bushes of the same variety which had been twice sprayed with "liver-of-sulphur" on *May 13th* and *May 26th.* Mildew also present on shoots and berries of many of the sprayed bushes of *Yellow Rough*, and on unsprayed bushes of *Freedom.*

June 12th.—Sky overcast; very close,—after storm; no bright sunshine.

June 23rd.—Clear sky; hot sunshine.

July 12th.—Bright, sunny intervals between heavy showers; close.

CENTRE: MEREWORTH.

PLOT I.—LANCASHIRE LAD.

The bushes were about ten years old, in a plantation shaded by fruit trees.

Before the experiments started, all the bushes had been sprayed six times by the farmer, the first three times with lime-sulphur, and then three times with "liver-of-sulphur" solution.

June 2nd.—(1) Fifty bushes sprayed with lime-sulphur, 1.01 sp. gr.
(2) Twenty-five bushes sprayed with "liver-of-sulphur" solution, 2 ozs. to 3 gallons water.

June 9th.—(2) As before.

June 21st.—(1) As before (a light spraying to cover the fresh growth).
(2) ,,

July 14th.—(1) ,,
(2) ,,

No injury resulted from the three applications of lime-sulphur, nor any serious injury from the four applications of the "liver-of-sulphur" solution. On *June 21st* a slight leaf-fall, somewhat sporadic, and nowhere to any serious extent, occurred on the bushes sprayed with "liver-of-sulphur" solution.

On visiting the farm on *June 2nd*, the mildew in its summer-stage was seen on a few berries, but after a careful search through all the plantations no mildew could be found on the leaves or shoots. The mildew was first seen on the shoots on *June 9th*, but owing to the hot, dry weather which followed, causing a "ripening" of the shoots, no serious spread of the mildew occurred during June.

On June 21st a trace of mildew was first observable in the sprayed plot, viz., on the shoots of many of the bushes which had been sprayed with "liver-of-sulphur," while no mildew was present on the lime-sulphured bushes. (On the bushes in another part of the plantation, which had not been sprayed since May, the mildew was thick on the young shoots of many of the bushes.) The weather conditions from about *June 10th* to *June 20th* were not favourable to the spread of the mildew; and on *July 14th* there was still no mildew on the lime-sulphured bushes, and less mildew on those sprayed with "liver-of-sulphur" than there had been on June 21st.

The berries, which were now ripe, were quite free from mildew; those on the lime-sulphured bushes were so marked by the spray that they could not have been marketed without treatment. Some of the worst affected ripe berries of these *Lancashire Lads*, together with some equally ripe and marked berries from the lime-sulphured *May Duke* bushes (see above, PLOT 4), were passed through Fletcher & Becker's "Gooseberry Cleaner" machine. By means of its ingenious arrangement of brushes, this machine removed the wash satisfactorily from

the sides of the berries, without bruising them, and so made the sample quite bright and of normal appearance; traces of the wash could still be seen on close inspection at the eye and round the stalk, or where a wrinkle occurred in the skin, but such minute spots would not, of course, affect the market value.

The weather conditions at the times of spraying at the Mereworth centre, and the dates of the appearance of mildew were as follows :—

June 2nd.—Hot sunshine ; slight breeze. The mildew was found in its summer-stage on a few berries, but a careful search failed to show any shoots affected at this date. The plantation in which the mildew was found had already been sprayed six times, the first three times with lime-sulphur, and the last three times with "liver-of-sulphur" solution.

June 9th.—Cloudy at times, alternating with bright sunshine tempered by cool wind. The mildew was now seen on the shoots.

June 21st.—Sky overcast, after storm ; close, no hot sunshine. No spread of the mildew to any appreciable extent had taken place ; the hot weather about this time caused a ripening of the young shoots which was unfavourable to the spread of the disease.

July 14th.—Sky overcast ; sultry ; rain in afternoon.

CENTRE: BOUGHTON-UNDER-BLEAN.

PLOT 1.—COUSIN'S SEEDLING.

The bushes were six to ten years old, in a plantation situated in the open.

May 15th.—(1) Twenty bushes sprayed with lime-sulphur, 1.01 sp. gr.
(2) Twenty bushes sprayed with lime-sulphur, 1.01 sp. gr., plus arsenate of lead* (at rate of 2 lbs. Swift's Arsenate of Lead Paste to 50 gallons).
(3) Sixteen bushes sprayed with "liver-of-sulphur," 1 oz. to 3 gallons water.

May 30th.—(1) As before (light spraying only, to cover the fresh growth).
(2) As before (light spraying only, to cover the fresh growth).
(3) As before (light spraying only, to cover the fresh growth).
(4) Eight bushes sprayed with lime-sulphur, *plus* arsenate of lead (as before).
(5) Three bushes sprayed with lime-sulphur, 1.01 sp. gr.

June 13th.—(1) As before.
(2) ,,
(3) ,,
(6) Fifteen bushes sprayed with lime-sulphur *plus* arsenate of lead (as before).

* The addition of arsenate of lead to lime-sulphur has been stated by experimenters in the United States to add considerably to the fungicidal property of the latter. Owing to the poisonous nature of arsenate of lead, such a mixture must not be used on fruit within at least six weeks of the time of picking.

June 26th.—(1) As before.
(2) Sprayed with lime-sulphur, 1.01 sp. gr. only.
(3) As before.
(4), (5), (6) sprayed with lime-sulphur, only, 1.01 sp. gr.
(7) Twenty-one bushes sprayed with lime-sulphur, 1.01 sp. gr.

July 8th.—(1) to (7) As before.

July 30th.—(1), (2) and (3) As before.

The mildew had been noticed somewhere in the plantation by the Kent County Council Inspector, during the first week in May. The first appearance of the mildew was noticed by us on May 30th, when it was found just beginning to develop on several of the berries and on one leaf of eleven bushes which had not previously been sprayed. Eight of these bushes were at once sprayed with lime-sulphur, mixed with arsenate of lead (see above, *May 30th*, (4)), and the three remaining bushes with lime-sulphur alone (5). On *June 13th* the mildew was checked on these eleven bushes. At that date, fifteen more bushes (not hitherto sprayed) were found attacked by mildew, and on some of the bushes the attack was severe, many of the shoots being quite white and powdery with the summer-stage. These fifteen bushes were sprayed with lime-sulphur mixed with arsenate of lead (see above, June 13th (6)). About June *26th* the mildew had appeared on twenty-one " control " bushes, which showed the tips of the shoots here and there affected with both summer- and winter-stages. These were sprayed with lime-sulphur, 1.01 sp. gr. (see June 26th (7)). The spread of the mildew became checked by a spell of hot, dry weather, which caused the shoots to turn somewhat red and ripen off. The forty bushes in (1) and (2) showed no mildew on them ; the tips of the shoots, which had now grown out, were lightly sprayed over again ; the sixteen bushes in (3) showed a slight trace of mildew on two of them ; the twenty-six bushes in (4), (5) and (6) showed no living mildew on them, but this fact may have been due to the unfavourable weather conditions ; the bushes in (7) showed only the patches of winter-stage still remaining. On July 8th there was no mildew in the spreading infectious summer-stage on any of the plots. On July 30th a trace of mildew in the summer-stage was present on the bushes which had received the " liver-of-sulphur " solution (3) ; very little fresh growth had been made by any of the bushes. At this date the berries were picked from the bushes (1) (2) which had received five successive sprayings with lime-sulphur—the last application having been on July 8th. The berries were a good deal marked by the wash as the bushes had been heavily sprayed ; the handling of the berries in picking them, however, removed a considerable amount of the deposit. Before being sent to market they were just rinsed in water ; no complaint was received from the salesman.

As at the Rodmersham centre, no injury whatever resulted from the six successive applications of " full-strength " lime-sulphur.

The weather conditions at the times of spraying at the Boughton-under-Blean centre, and the dates of the appearance of the mildew were as follows :

May 15th.—Cloudy ; no sunshine all day ; cold N. wind.

May 30th.—Hot sunshine ; sultry except for a warm wind blowing. The mildew found on several berries, and on one leaf, of eight unsprayed bushes.

June 13th.—Overcast sky ; close. The mildew occurred on fifteen more unsprayed bushes, and some of their shoots were virulently affected with the summer-stage.

June 26th.—Hot sunshine ; close. The remaining twenty-one " control " (unsprayed) bushes were now all attacked by mildew, in both the summer-stage and also (on a number of the shoots) in the winter-stage as well. These bushes were certainly attacked at some date since *June 13th*, and the mildew had developed fully its winter-stage by *June 26th*. About this date the shoots of the bushes generally began to redden and ripen, as the result of the hot weather, and this had the effect of stopping the spread of the mildew.

July 8th.—Bright sunshine, not very hot.

July 30th.—Sky overcast ; no sunshine ; cool.

The experiments carried out in the United States have indicated that the sprays containing sulphur are more efficacious in stopping the spread of American Gooseberry mildew in the summer stage than those containing copper. In America the " liver of sulphur " solution, at the strength of one ounce to two gallons of water, with about seven applications at intervals of ten to twelve days, is generally recommended as the best fungicide. It is quite clear, however, that in this country this spray, even when of greater strength and applied at shorter intervals, is powerless to check the spread of the mildew in severe outbreaks, and the lime-sulphur wash has given decidedly better results. Lime-sulphur, too, has the great practical advantage over the " liver of sulphur " wash, and over " flowers of sulphur," that it is, when once dry on the bush, so remarkably adherent that even heavy rains do not wash it off. It is very probable that " flowers of sulphur " would prove as efficacious in the summer in checking the spread of the American Gooseberry mildew as it has proved against the very closely allied Hop mildew (*Sphaerotheca Humuli*). It must be remembered, however, that " flowers of sulphur " is efficacious in dealing with the Hop mildew apparently only in periods of sunshine and high temperature, and also that rain removes it at once.

It is obvious, therefore, that " flowers of sulphur " is very unsuitable for use in spring, when frequently there are long periods of low temperature and showers nearly every day. It is intended, however, to experiment next season with " flowers of sulphur " to ascertain if this will keep off the mildew in summer from the crop of late dessert varieties of gooseberries. It may be pointed out here that the recommendation frequently given in the horticultural press to use a mixture of slaked lime and sulphur cannot be supported on either chemical or biological grounds. Slaked lime and sulphur, when mixed at the ordinary temperatures do not interact chemically, so that the addition of such lime to sulphur will only mean the application of a smaller quantity of sulphur. Recent experiments have shown that the fungicidal action of lime and sulphur is very considerably less than that of sulphur alone. Where the two were tried against Hop-mildew, the following results were obtained :—

	HOPS.					
	Free from mildew.		Slightly affected.		So badly affected as to be valueless.	
	Number.	%	Number.	%	Number.	%
Sulphur	1296	61.2	610	28.8	213	10.0
Lime and Sulphur ..	535	12.3	1273	29.4	2530	58.3

The author of the *Bulletin** remarks : " The above results are of some interest in connection with the theory of the action of sulphur. A considerable amount of work has been done which seems to indicate that the action of sulphur is due to the gradual oxidation of the sulphur, forming sulphurous acid in the presence of water, which in turn is oxidised to sulphuric acid. These acids in dilute solutions have been shown to destroy the mildew. In the presence of lime these acids would naturally unite with the lime, forming compounds quite insoluble and presumably quite harmless to the parasite."

* Bulletin 328, Cornell University, Agric. Exper. Station (1913).

Owing to the remarkably adhesive properties of lime-sulphur, the fruit of sprayed bushes becomes much marked by the dried wash. The degree of disfigurement of the crop varies a good deal according to the nature of the berry in the different varieties. In one case where some bushes of *Gunner's Seedling* and *Cousin's Seedling* were sprayed lightly with "half-strength" lime-sulphur on June 17th, the berries, when ripe on July 28th, showed a noticeable amount of deposit, particularly in the case of the *Gunner's*. The marks in this case, however, were rubbed off to a considerable extent in the process of picking, and the berries were marketed without treatment, and no complaints were received. In another case, berries of *Cousin's Seedling* were picked for market on July 30th, from bushes which had been heavily sprayed with lime-sulphur at "full strength" on July 8th. Although the berries when on the bushes were much marked with the whitish sediment of the wash, the handling of them in the operation of picking removed a good deal of it. These berries were then just rinsed in water, and marketed, and no complaints were received. With other varieties, however, *e.g.*, with Lancashire Lad, it is more difficult to clean the berries. In such cases either repeated rinsings in water must be given or the crop passed through the lately-invented Fletcher and Becker "Gooseberry Cleaner." One type of this machine grades the berries as well as cleans them ; on farms where there is a large acreage of gooseberries, or in a district where co-operative marketing has been organized, the better prices obtained through the grading would in all probability justify commercially the adoption of this machine.

It may be well to point out here that there is no danger to the public health in the marketing of berries sprayed with lime-sulphur. Sulphur is not a poison, and in the very small quantities present on such berries could not possibly cause any disagreeable effects. Some berries of *Howard's Lancer* so heavily sprayed with lime-sulphur as, when dry, to be covered continuously all over with the whitish deposit, were boiled with sugar as in the ordinary domestic cookery ; no objectionable smell was given off during the cooking, and the berries when eaten had no objectionable taste or unpleasant after-effects.

II.—*Observations on the Life-history of the American Gooseberry Mildew.*

Some new scientific facts of practical importance were noted at the beginning of last August in a plantation where the crop was badly affected. On examining the berries it was found that the ripe fruit-bodies (*perithecia*) had become free from the threads (*hyphae*) of the brown scurf-like spawn (*mycelium*) investing the diseased fruit, and now fell readily to the ground. On a mildewed berry being gently tapped over a piece of white paper, hundreds of just visible black "specks" could be observed on it; these put under the microscope were found to be ripe fruit-bodies (*perithecia*) containing mature winter-spores (*ascospores*). Experiments showed that such ripe perithecia, when kept supplied with moisture for a few days, and at ordinary room temperatures, open by a slit in the wall, and the contained sac (*ascus*) with its winter spores (*ascospores*) swells and protrudes (see Fig. 2). In a short time the wall of the *ascus* breaks at the apex, and the *ascospores* are forcibly discharged. It is very probable that with suitable weather conditions this discharge of winter-spores takes place in mid-summer in the plantation; if so, such winter-spores will serve to spread the disease the same season that they are produced.* It is probable, too, that many of the fruit-bodies (*perithecia*) that fall to the ground from the diseased berries will remain dormant in or on the soil until the following spring, when they will cause new outbreaks of disease.

With these fresh facts to hand, it becomes a matter of great practical importance in fighting the mildew not to allow berries with any brown winter-stage on them to remain on the bush, as there will always be the serious danger of the soil under the bushes becoming heavily infested with winter-spores (*ascospores*),—in which case spraying the next season would probably be of little avail in keeping off the mildew from the berries (see above, p. 25). To some extent, also, the fruit-bodies (*perithecia*) begin to drop in August from the patches of mildew in the winter-stage which have been formed

* I have proved that this can take place in the case of the allied mildew, *Erysiphe Graminis*, on corn and grasses.

on the shoots. As to how far this dropping to the ground of the fruit bodies (*perithecia*) in summer is exceptional or not,—whether, *e.g.*, it occurs only when the winter-stage has been formed very early in the season, or whether it is dependent on some special weather conditions at a stage in the development of the mildew,—are points to be ascertained by future

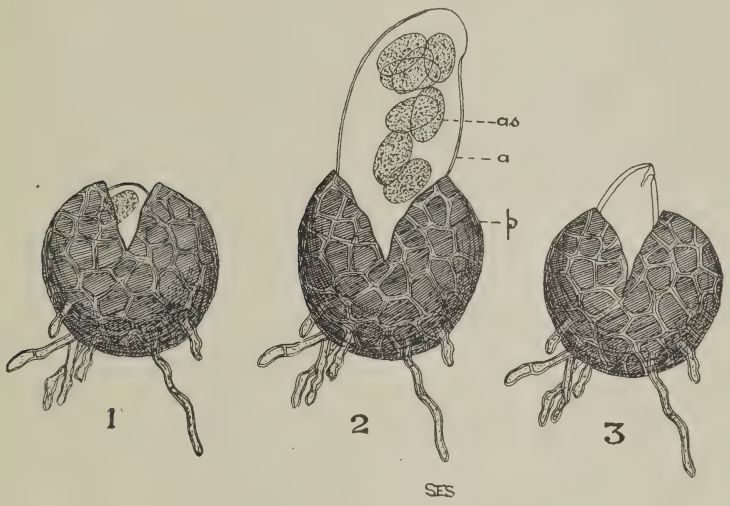

Fig. 2.

Three stages in the dehiscence of the *perithecium* of the American Gooseberry-Mildew.

p=*perithecium* ; *a*=*ascus* ; *as*=ascospores.

(Highly magnified.)

1. The perithecium splits open by a crack at the apex ; the enclosed ascus begins to swell and protrude through the opening.
2. The stage reached in about five minutes. The ascus has swollen enormously, and in consequence its wall is in a state of great tension. After a short time, as the result of increased tension, the wall of the ascus bursts near the apex, where the wall is thinner, and the eight ascospores are expelled forcibly into the air to a distance of about one inch.
3. Directly the ascospores are shot out, the empty ascus, now reduced in size, shrinks back into the perithecium.

investigations. It is certain, however, that during the past season there was an infestation of the ground taking place in August in many plantations in Kent, where late dessert varieties of gooseberries are grown.

Another fact of considerable practical importance was the very frequent occurrence during the past season of the winter-stage of the mildew *on the leaf* of the gooseberry. In cases where the shoot was severely attacked, the young leaves were arrested in growth and became ultimately continuously covered over with the brown winter stage of the fungus (see photograph in Plate II.). Shoots with the leaves affected in this way could be found by the hundred during August in badly affected plantations in many parts of Kent. In other cases, of equally common occurrence, the leaf itself was not affected in size or shape, and the infestation was confined to the lower part of the leaf stalk, where a small brown patch of the winter-stage occurred. In both cases, if such diseased leaves are allowed to fall to the ground, they cause inevitably an infestation of the soil, with the result that next spring the winter-spores rising from the ground, give rise to fresh outbreaks of mildew. To prevent this infestation of the soil it is desirable to "tip" in August before the leaves fall.

Another point in the life-history of the mildew, not sufficiently recognized hitherto, is the fact that the winter-stage may be developed almost at the very beginning of an attack. This is a fact of great practical importance, and one that makes the control of the mildew by spraying alone practically impossible. Two cases, out of many observed during 1913, may be noted here in detail. On *May 26th* some bushes of *Cousin's Seedling* which were under observation showed no mildew; on *June 6th*, these bushes, nineteen in number, were all infested with mildew, and on three of these bushes the winter-stage was already well-developed. In this case, then, inoculation and the incubation period and the development of the winter-stage had all taken place in not more than eleven days. Again, on *June 13th*, some bushes of *Cousin's Seedling*, which had been kept under observation on another farm, were quite free from mildew; on *June 26th*, all these bushes (twenty-one in number) had mildew on them, in both the winter and summer-stages; here the period was thirteen days. The fact, too, of the appearance of the winter-stage sometimes very early in the season undoubtedly

makes the work of combating the mildew more difficult. As noted above, the winter-stage was found in a plantation of *Cousin's Seedling* in Kent last season as early as *May 26th,* and by *June 6th* it was found in a mature condition on numerous bushes of several varieties. In 1912 in Kent the winter-stage with ripe winter-spores was found on *July 17th* on both the leaves and shoots of the Red Currant.

With the fact of the almost simultaneous appearance of the summer- and winter-stages at all times of the season, it is quite obvious, since, on the one hand it is commercially impossible to keep all the shoots of the buds continuously sprayed throughout the growing period, and, on the other hand, that no spraying with lime-sulphur or any other known spray will kill the winter-stage, that some amount of "tipping" to remove the winter-stage will always be absolutely necessary. As I have pointed out below, early "tipping" must be looked upon as a measure of primary importance, and spraying at certain times only as a valuable adjunct.

III.—*General Remarks and Conclusions.*

It will probably be conceded now that the American Gooseberry-mildew has "come to stay" in this country, and that to some extent new methods of cultivation will be necessary in order to place the growing of Gooseberries on a safe commercial footing. Where Gooseberries are being grown under the shade of trees, so closely crowded that no spraying can be done, they are so "housed in" that the lack of ventilation and the delayed drying of the bushes and soil after rain, mists or heavy dews, cause outbreaks of the mildew to assume at once epidemic proportions and all such plantations are doomed. The plantations likely to prove commercially successful in withstanding the attacks of the mildew are those in which the following conditions of cultivation are found :—(1) An open situation. (2) Bushes not too closely planted. (3) Bushes of a variety that will not be injured by spraying. (4) Bushes with a natural unforced growth, such as is obtained naturally in a good soil, or by well-balanced

manuring. Over-nitrogenous manuring, *e.g.*, heavy dressings of organic manures, forces the bushes into producing sappy shoots which become virulently attacked by mildew. Experiments with the best commercial varieties should be undertaken to ascertain whether " spur "-pruning, under which system the tipping of diseased shoots (which is absolutely necessary in combating mildew) does not reduce the next season's crop, has advantages from the point of view of dealing with the present disease ; or whether the abundance of young shoots which result from " spur "-pruning becomes a serious handicap. At any rate, varieties such as *Cousin's Seedling*, should be pruned in such a way as to encourage an upward growth of the branches.

With regard to the direct methods that can be employed against the mildew, it is clear that the early removal and destruction of the diseased shoots and berries is essential for success. Mildewed berries must be removed before the ripe winter-stage has formed on them. Spraying with lime-sulphur on the lines indicated below may prove to be a valuable help, but it comes second in value to the removal of the shoots and berries. If through negligence the early removal of the affected shoots and berries is not carried out, and the soil thereby becomes infested with the fruit-bodies (*perithecia*) containing the winter-spores, repeated sprayings may be powerless to save the crop or prevent outbreaks on an epidemic scale.

The lime-sulphur spray at full strength (1.01 sp. gr.) can be used during the early part of the season—April to June, and probably during July in most years—on the following varieties without causing any serious injury, even when applied several times successively to the same bushes :—*Whinham's Industry*, *Rifleman*, *Warrington*, *May Duke*, *Howard's Lancer*, *Gunner's Seedling*, *Cousin's Seedling* (*Sandwich Yellow*), and when growing in a shaded position, *Berry's Early* and *Lancashire Lad*. The following varieties are liable to be injured if the bushes are sprayed many times successively, or if they are situated in a sunny position : *Berry's Early*, *Freedom*, *Lancashire Lad*, *Crown Bob* ; it is advisable, therefore, to use half-strength lime-sulphur (1.005 sp. gr.) on these varieties and to avoid sprayings late in the season. The varieties *Yellow Rough*,

(*Golden Drop*) and *Valentine's Seedling* show so marked a susceptibility to injury that they cannot be sprayed. In early seasons the spraying should be commenced in the middle of April, in plantations where the disease appeared in the previous season, under other circumstances, the first week in May is early enough ; the spraying should be continued at intervals of about a fortnight until it interferes with the marketing of the fruit (see above, p. 37), when " liver of sulphur " solution or " flowers of sulphur " should be tried to stop the spread of mildew to the fruit. By this means it should in most cases be possible to grow a clean crop of berries. In cases, however, where the soil has become infested, it will probably be found that the berries become mildewed in spite of spraying.

Whilst spraying in May and June with lime-sulphur *before the mildew is on the bushes* appears to be with many varieties a practical way of preventing infections taking place early in the season and saving the crop, it is certain that the spraying of good-sized gooseberry bushes throughout the growing season is not commercially advisable. Even if by this means it were possible to keep the mildew entirely off the bush (which is extremely doubtful considering the constant growing out of the shoots) the cost in labour of the repeated applications would be prohibitive. It must be remembered that neither lime-sulphur nor any known spray kills the winter-stage of the mildew, and, as was observed repeatedly during 1913, outbreaks of mildew frequently occur in which the winter-stage suddenly appears almost simultaneously with the summer-stage (see above, p. 40). It is practically certain, therefore, that in every case of mildew in a plantation, some " tipping " of diseased shoots will require to be done. After the crop has been gathered, a good final spraying with lime-sulphur should be given. The mildew must then be allowed, in most cases, to attack the later growth of the shoots. By August a greater or less amount of disease will probably be found on the tips of the shoots : and this amount of disease must be expected until far more thorough and systematic methods of control are devised and generally adopted. With young and valuable Gooseberry plantations close attention to the date of the first appearance in them of

mildew and repeated sprayings to cover all the fresh growth made may render it possible to rear the bushes without having to "tip" them for disease to an extent that will seriously injure their growth. Such raising of young plantations will be possible, however, only if each season the diseased tips of the shoots are collected and destroyed in good time.

Taking everything into consideration, tipping in August or early in September, before the leaves have fallen, is strongly to be recommended in all cases where anything like a severe attack of mildew has occurred. In some seasons, and with bushes of a certain age, no further growth of the shoots will take place after the tipping is done (see above, p. 30), and then if all the mildew has been cut off, the bush stands perfectly healthy again, since the disease is strictly external and on the young wood only; if, as will be probable in some seasons, some slight fresh growth is made and this becomes infected with mildew, the grower will still be in a better position, since there will certainly be much less disease to be removed before the fruit-bodies (*perithecia*) with their winter-spores fall to the ground, or even should this happen in consequence of the postponement of the second "tipping" through an unavoidable scarcity of labour, there will be a much less severe infestation of the soil than if no tipping at all were done until October or November. On many large fruit-farms, as well as on small holdings, it is possible to find labour for the "tipping" of the shoots during the early part of August (before apple picking begins). It should be realized by the commercial fruit-grower, with the evidence which has now been collected as to the progress of the disease in this country, that it will pay better to go over infected gooseberry plantations in August and carefully remove and burn all diseased tips than to wait until late autumn, when first again there is labour for the operation. For if the tipping is done in August, the diseased leaves (with their winter-spores in the fruit-bodies (*perithecia*)) will be prevented from falling to the ground, and further, the diseased shoots also will be destroyed before the fruit-bodies have begun to fall to any considerable extent from them.

With strict attention paid to the collection and destruction

of all berries which show any " winter-stage " on them*, and to the tipping of the diseased shoots in August, and by the help of spraying early in the season with lime-sulphur, it should be possible and commercially practicable to grow a crop of gooseberries free from mildew. On small holdings, and on bigger farms where gooseberries are grown in open plantations, and where sufficient labour is available at the necessary times, gooseberry growing can still be practised with hope of success, but only if the altered conditions of culture due to the introduction and establishment in this country of American Gooseberry-mildew are carefully borne in mind.

* There is no danger of the soil becoming infested from berries which have only the *white* " summer-stage " on them ; but as soon as they show any *brown* " winter-stage " the crop should at once be picked and marketed, after the berries have been looked over and the mildewed ones destroyed.

OBSERVATIONS ON THE LIFE-HISTORY OF THE AMERICAN GOOSEBERRY-MILDEW.*

(*Sphaerotheca mors-uvae* (Schwein.) Berk.)

By E. S. Salmon.

The rule among the species of *Erysiphaceae*—to which the American Gooseberry-mildew belongs—is a life-cycle consisting of the production of a *conidial* stage during the growing period of the host-plant, and the production before the advent of winter of a *perithecial* stage. In the *conidial* stage the spore is a naked, short-lived *conidium*; in the *perithecial* stage the spore is an *ascospore*, which remains living for several months within the *ascus* inside the thick-walled *perithecium*.

While this is the usual life-cycle, some striking exceptions occur, particularly in cases where a species has found its way into a new continent.

When the Vine Mildew (*Uncinula necator* (Schwein.) Burr.) invaded Europe, no *perithecial* stage was found associated with it for the first forty-seven years, the mildew existing during winter in the *conidial* stage in a more or less dormant condition. Appel has shown that before winter patches of hibernating mycelium are formed on the stem of the vine; these produce *conidia* the next season. These hibernating patches have thicker-walled hyphae, and more numerous and larger haustoria. Although the perithecial stage of *U. necator* has been found within recent years on a few occasions in different years in France, Germany and elsewhere, it appears that the production of *perithecia*—which are found abundantly in America, the native home of this mildew—only takes place exceptionally in Europe—possibly under abnormal weather conditions.

* Read at the Meeting of the Association of Economic Biologists, held in London, on April 17th, 1914.

A very similar case is that of the Oak Mildew. About ten years ago oak " scrub " and to some extent oak trees also, in England and in many parts of the Continent, became for the first time attacked by a species of *Erisiphaceae* in the *conidial* stage. It received many names, *e.g.*, *Oidium alphitoides*, *O. quercinum*, etc., at the hands of mycologists belonging to that class which has sufficient time only to add to synonymy. In 1911, the discovery in France of the perithecial stage of this mildew on some autumnal shoots of the oak proved its identity with an endemic American form of *Microsphaera Alni* (Wall.) Salm., which occurs commonly, on species of *Quercus* in the United States. Here, again, quite exceptional seasonal conditions would seem to be necessary for the formation of the perithecial stage of this mildew when introduced—as presumably has been the case—into Europe from America. No perithecia have been found in this country and certainly as a general rule the oak mildew passes the winter in the conidial or mycelial stage in a more or less dormant condition.

A third case is the mildew which attacks the foliage of that very useful ornamental shrub *Euonymus japonicus*. This mildew first appeared in England, and also on the Continent, about fifteen years ago, and only the conidial stage is known.* It is possible that it is a form of *Erysiphe Polygoni* endemic to Japan on *Euonymus japonicus*, and that it has been imported with that shrub from Japan into Europe. The mildew exists in Europe during the winter-months on the evergreen leaves in dormant or nearly dormant hibernating mycelial patches which on the advent of a warm spell of weather soon produce *conidia*.

What now are the facts with regard to the life-cycle of the American Gooseberry mildew (*Sphaerotheca mors-uvae* (Schwein.) Berk.) in this country since its introduction into Europe from America about 1900? Has its normal life-cycle been interfered with in any way as the result of new factors such as change of climate or different " constitutional " characters of its host-plants? There is, I think, some reason for thinking that it has. There is no evidence that there is any hibernation of the conidial stage. The perithecial stage—

* Salmon, E. S.; " Fungous Diseases of *Euonymus japonicus* " (Journ. Roy. Hort. Soc., XXIX., p. 434, 1905).

or at least the outward signs of it—is formed abundantly on the surface of the young shoots of the gooseberry. It has been assumed from the first—and quite rightly so under the circumstances—that the continuance from year to year of this new and most destructive pest was everywhere ensured by this abundant production of the perithecial stage. Some facts which I have lately observed, however, show the necessity for close investigations to be made to ascertain to what extent the perithecial stage which is formed at different times during any one season remains living through the following winter and is the cause of the first spring outbreaks. The facts lately observed seem to show that there is a real danger—if the American Gooseberry-mildew orders are carried out by officials without the guidance of a mycologist—of fruit-growers being prosecuted and fined for not removing from gooseberry bushes *the mildew in a dead condition.*

In August last year, and during the present spring, I have observed the various details connected with the dehiscence of the ripe perithecium and the discharge of the ascospores—a process which I have not before succeeded in observing and one which, I believe, has escaped other investigators. These details are described below (p. 53). The dehiscence of the ripe perithecium was observed to take place in material collected last August, a few hours after the perithecia had been supplied with moisture; similar material, collected in November last, and kept dry in the laboratory through the winter, proved when examined in February, March and April to be alive, and the perithecia dehiscing when supplied with moisture.

This living material was useful in affording a comparison with examples of the perithecial stage obtained from bushes in the open in the spring, *i.e.*, after it had "wintered." In all cases, so far, such "over-wintered" material, which has been obtained from N., Mid., and E. Kent,* proved in February or later to be dead. In such material the perithecium on being pressed open usually exudes drops of an oily nature; the ascus is not turgid, and is often more or less crumpled; the ascospores are filled with some oily material, staining pink with

* Most of this material was kindly sent to me by Mr. F. G. Cousins, Inspector for American Gooseberry-mildew for Kent.

alkannin. No development can be induced on "incubation" at temperatures which cause living perithecia to dehisce and discharge their spores, and it is clear that such perithecia are dead.

Another lot of material was collected at the end of April, from Farnham, Newdigate and Witley. Thirty-four shoots bearing patches of the perithecial stage were sent; they were all microscopically examined. Twenty-two shoots bore patches of deep brown persistent mycelium, which on examination proved to be either quite barren with no perithecia, or with just a few (dead) perithecia. The appearance of the barren patches suggested that no peritheca had ever been formed, *i.e.*, that the development of the winter-stage had been stopped, and not that the perithecia had fallen out from them, since the densely interwoven mycelial patches showed—in many cases at all events—no signs of having been worn thin or disintegrated under the action of weather conditions; in a few cases the mycelial patches may have been partly worn away as the result of "weathering." On more than fifty per cent. of these diseased shoots there was a completely barren, although dark brown, mycelium. In the remaining twelve examples perithecia had been produced abundantly on the shoots, but in no case was a living ascus found inside any perithecium. In several cases the perithecia had apparently never reached their full development, since the ascus was not the normal size; in those cases where a full-sized ascus was present, it was without exception shrunken and obviously dead, and the ascospores, which contained oil-drops, were evidently undergoing a process of degeneration.

On May 4th a commercial plantation of *Berry's Early*, near Rodmersham, Kent, was visited at a time when the American Gooseberry-mildew was just beginning to appear for the first time this season. A number of bushes were found with the (conidial) summer stage of the mildew developing, mostly on the young green berries. In a considerable number of cases—perhaps in the majority of cases—the affected berries were in close proximity to portions of last year's shoots which were badly infested with the ("over-wintered") perithecial stage. On microscopical examination, however, of nine of these shoots, *i.e.*, where mildewed berries occurred

close to the winter-stage formed in 1913—all the perithecia appeared to be dead, the ascus being either shrivelled or empty, or when containing ascospores the ascus was not turgid, and the spores were full of oily degeneration products. The perithecium on being pressed open usually exuded drops of some oily substance.

On other branches of the bushes which bore the mildewed berries, and also on other adjoining bushes where no mildew occurred yet, the perithecial stage of 1913 could be found not uncommonly on several of the young shoots (although the bushes had been gone over twice in the process of " tipping "). As in the above-noted cases, the perithecial stage consisted of the dark-brown persistent mycelium, often considerably worn away by " weathering," and hundreds of closely aggregated perithecia. Thirty-two of these shoots with the perithecial stage were examined, and not one perithecium could be found with a living ascus. The experiment was made of incubating some of this material at 27° C., but no change resulted.

On May 6th a commercial plantation of *Cousin's Seedling* near Sandwich, Kent, was visited. This plantation was so virulently attacked by the mildew in 1913 that practically all the young shoots in every bush became infested with the winter-stage, and this also was developed on nearly every berry—the whole crop was lost, not a single berry being fit to pick. An examination on May 6th showed that the disease was just re-starting for the season ; from forty per cent. to fifty per cent. of the bushes (250 in number) bore a few berries with small patches of the conidial " summer-stage " on them. In a few cases young shoots more or less plentifully infested with the perithecial stage of 1913 were closely adjacent to these mildewed berries. Nine of these shoots were microscopically examined, but no perithecium containing a living ascus was found. In the majority of cases the ascus was empty and shrivelled ; in a few cases where ascospores occurred, the ascus was not turgid, and the spores were full of oily contents, and evidently undergoing a process of degeneration. In a very few cases the perithecium contained the spores of the parasitic fungus *Ampelomyces quisqualis*, but it was clear that the mildew had not been

parasitised to any appreciable extent. With regard to the bushes generally, the mildewed berries were found either on branches from which all the young wood (which had probably been diseased) had been cut away, or on spurs on quite old wood.

Since there is no evidence that in these cases the primary infections have been caused by ascospores from the "overwintered" material still present on some of the shoots, the explanation must be looked for in another direction. There are two other ways by which infection by ascospores could have occurred. As I have pointed out (see above, p. 38), perithecia may begin to fall to the ground in August from infested berries and, to a less extent, from infested shoots. With regard to this particular plantation, all the berries (as noted above) became very badly infested; they were not removed by the grower until late in August, by which time not only must thousands of perithecia have fallen to the ground, but many of the infested berries had fallen or been scattered by birds; there must, therefore, have been a heavy infestation of the soil. If, however, the primary infections which were taking place in May had been caused by ascospores arising from the soil, one would have expected to find the majority of the mildewed berries on the lower branches of the bush, *which was certainly not the case, the affected berries being nearly always on the upper branches.*

The second way by which infection could have been caused is as follows. The "tipping," *i.e.*, the removal of the infested shoots was not done until the end of October or beginning of November; by this time a considerable mass of perithecia must have dropped from the perithecial patches. Many of these perithecia would doubtless lodge in the crevices of the bark, or between the bud-scales, etc., and assuming that these perithecia (developed, perhaps, in the *first-formed* patches) were mature ones capable of remaining dormant through the winter, these would on liberating their ascospores, infect the adjacent berries. This theory, to which on the whole I incline, would account for the fact that the berries in the upper part of the bush were first attacked.

It seems clear, therefore, from the evidence given above, that some amount of the perithecial stage of the American

Gooseberry-mildew which is produced in this country either does not reach maturity or does not survive the winter.

It is possible, but I think very unlikely, that in those cases (mentioned above) where an examination in the spring showed only perithecia with dead asci that all the mature (living) perithecia had fallen previously to the ground. It seems far more probable that this material had never reached that stage of development at which the perithecia can remain alive through the winter. If so, the reason for this failure to mature may be due to the influence of new factors which the mildew encounters in this country, such as the "constitutional" characters of European varieties of gooseberries, or to the weather conditions obtaining in this country in the late summer or autumn. It may possibly prove to be the case that it is only the perithecial stage which is formed early in the season reaching maturity about July or August, that is really dangerous, and that later-developed perithecia do not survive the winter.

It would of course be unwise to generalize from observations—made so far on material obtained in one season only; but there seems clear evidence that both the fruit-grower and the official administrators of the American Gooseberry-Mildew Orders have a new fact to reckon with, viz., the natural death before the spring of some amount of the perithecial stage of the American Gooseberry-mildew.

OBSERVATIONS ON THE PERITHECIAL STAGE OF THE AMERICAN GOOSEBERRY-MILDEW.*

(*Sphaerotheca mors-uvae* (Schwein.) Berk.)

By E. S. Salmon.

So far as I am aware, the manner of the dehiscence of the perithecium of *Sphaerotheca mors-uvae* has not hitherto been described.

During the spraying experiments against the American Gooseberry-mildew which were carried out last year in Kent, it was observed that the fully developed winter-stage occurred on both the berries and young shoots of gooseberry bushes at the beginning of August. The perithecia, which were perfectly mature, readily separated from the persistent mycelium; indeed, a considerable number were already loose, as was shown by the fact that if infested berries were held over a white sheet of paper and gently tapped, the perithecia fell in dozens on to its surface. The separation of the perithecium from the mycelium at this early date is a point of considerable practical importance in the control of the disease, indicating as it does the absolute necessity for the collection and destruction of mildewed berries before the winter-stage has matured on them, as otherwise the soil will become infested. Perithecia from this material when supplied with moisture were found to dehisce and eject the ascospores within a few hours. It seems probable, therefore, that in some cases the ascospores of *S. mors-uvae* may serve to spread the disease in the same season in which they are produced, as I have proved is sometimes the case with *E. Graminis*.

Similar material, showing the fully-developed winter-stage, was collected in November last, and it has been found that

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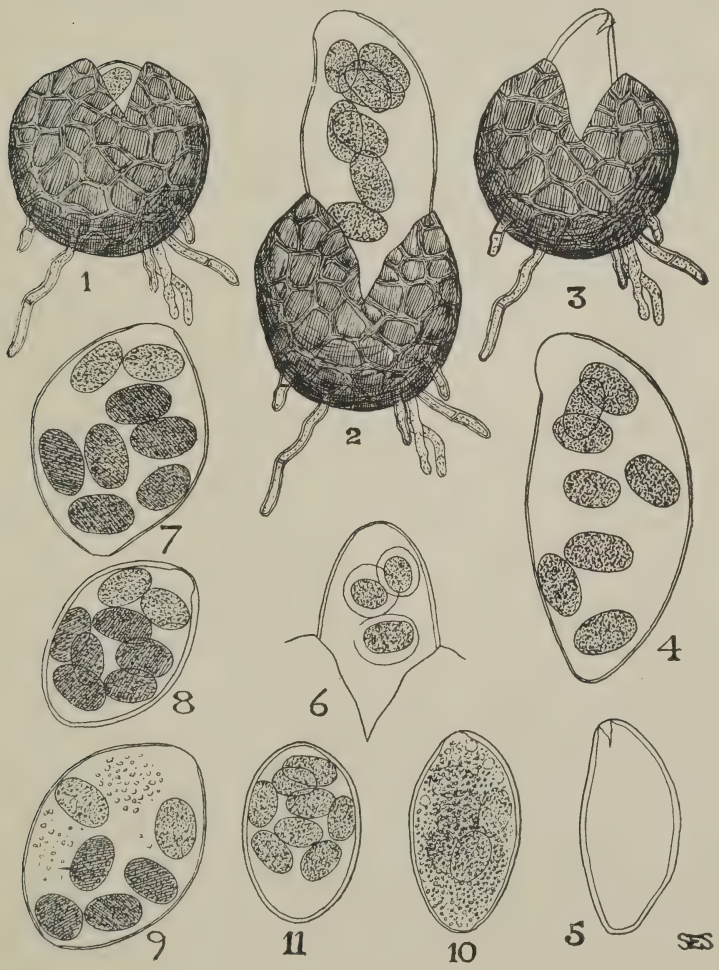
this, when kept dry in the laboratory (temperature about 15° C.) remains living through the winter. In February many of the perithecia when supplied with moisture opened and the ascus discharged its spores,—the whole process taking place within a few hours. The manner of the dehiscence of the perithecium and the swelling up of the ascus and discharge of the spores, as it takes place in a drop of water, can be seen on reference to Figs. 1 to 3, drawn under the microscope. A small more or less vertical slit appears at the apex of the perithecium, allowing at first only the tip of the enclosed ascus to be seen (see Fig. 1). The ascus rapidly absorbs water and swells considerably, emerging more and more into the open, and thereby exposing to view its ascospores. Through the forcible swelling of the ascus, the slit in the walls of the perithecium is enlarged. In about five minutes the ascus has swollen enormously, being now often double the length of what it was inside the perithecium (see Figs. 2, 4, 5). In the process of swelling its wall naturally becomes thinner and thinner; finally the tension becomes so great that the wall is ruptured near the apex of the ascus, at a place where from the first the wall is much thinner, forming there a kind of "pore" (see Fig. 9). Through the slit the eight ascospores are forcibly shot out all together. I have seen them expelled through water to a distance of about ten times the diameter of the perithecium, and from a perithecium laid on wet filter paper the spores will be discharged to a distance of 2.5 cm. The ruptured and empty ascus, greatly reduced in size, shrinks back into the perithecium, the walls of which at the slit come nearer together (see Fig. 3). If, as sometimes happens when the perithecium is in water, the ascus gradually emerges entirely from the perithecium, the process of the discharge of the spores takes place in the same way.

The length of time taken by the ascus in discharging its spores (when the perithecium is immersed in water) varies, as the following observations show.

Obser. 1. 12.53 p.m., Perithecium dehisced; apex of swelling ascus just visible (as in Fig. 1). 12.54 p.m., ascus emerged sufficiently to show 3 ascospores. 12.55 p.m., 6 ascospores visible. 12.57 p.m., clear vacuole-like spaces (see below) now apparent round most of the spores. 1 p.m., 8 ascospores now visible; ascus fully extended (as in Fig. 2). 1.5 p.m., ascospores discharged.

Obser. 2. 3.43 p.m., Perithecium dehisced. 3.44 p.m., ascus emerging and showing 2 of the ascospores. 3.45 p.m., ascus further emerged, and showing 4 ascospores, with clear vacuole-like spaces round two of them. 3.48 p.m., 8 ascospores visible, most of them surrounded by clear vacuole-like spaces. 4 p.m., ascus apparently fully extended, wall very thin. 4.29 p.m., ascospores discharged.

In a third case, the length of time from dehiscence to expulsion was 11 minutes.



Explanation of Figures.

Figs. 1—3. A perithecium of *S. mors-uvae* (in water), showing the manner of the dehiscence and discharge of the ascospores. Fig. 1. The wall splits at the apex of the perithecium, exposing to view the apex of the ascus, which immediately begins to swell up and protrude Fig. 2. The stage reached in about five minutes; the ascus has now swollen to about six times its original volume, and in so doing has enlarged the opening in the wall of the perithecium; the wall of the ascus in consequence of the enlargement has become very thin and is in a state of great tension. The ascospores are clearly visible in the hyaline contents of the ascus. Clear vacuole-like spaces (not shown here) are formed round the spores during the process of the swelling of the ascus (see Fig. 6). When the ascus has swollen to its full extent, the wall, after a little time, splits by a slit at the apex, at a place (or "pore") where from the first the wall is thinner (cf. Fig. 9), and the ascospores, all together, are forcibly expelled. The empty and shrunken ascus, now showing again the thick wall, retreats partly into the perithecium, the walls of which draw together somewhat at the opening.

Fig. 4. A fully swollen ascus, which has slipped out of the perithecium into the surrounding water.

Fig. 5. The same ascus as in Fig. 4, after it has discharged its ascospores.

Fig. 6. A ripe ascus beginning to swell up; clear vacuole-like spaces are formed round the ascospores.

Fig. 7. A ripe ascus swollen up in water; on treatment with the neutral red stain, six of the ascospores (shown shaded) became deeply stained, while two remained unstained.

Fig. 8. The same ascus, contracted on treatment with a solution of common salt.

Fig. 9. The same ascus on treatment with distilled water; two of the stained ascospores burst.

Fig. 10. An ascus, which was previously of the size and appearance shown in Fig. 2, contracted as the result of pressure (see p. 59). The contents (excluding the ascospores), which were before hyaline, are now densely granular, so that the outlines of the spores are almost hidden.

Fig. 11. The same ascus as in Fig. 10; after treatment with a solution of common salt, which causes the granular substances to dissolve.

The following facts are summarized from Exper. 2, given below in detail (see p. 58). Perithecia continued successively to dehisce over a period of nineteen days, after variations of temperature from 15.5 C. to – 1° C. With a temperature as low as 4.5° to 3° C., and as high as 27° C., the perithecium dehisces and discharges its spores. A temperature of –1° C., repeated five times, does not kill the ripe, or nearly ripe, perithecium.

In the following experiments the perithicia were kept on wet filter paper in a Petri dish, and placed so as to be about 5 mm. below the lid. The ascospores on being expelled were caught either in the drops of condensation on the lid or in agar, and were counted under the microscope and then removed after each observation.

Exper. 1. At 10.30 a.m. Feb. 12th, material of the winter-stage (taken from bushes last November, and subsequently kept dry in the laboratory) was wetted and placed immediately on wet filter-paper in three Petri dishes. These were put in the following positions: (1) out-of doors, in the shade. The maximum temperature during the day was 13° C.; (2) in the laboratory, temp. 15° to 16° C.; (3) in an incubator, temp. 27° C. By 12 noon the number of ascospores which had been discharged was as follows: (1) 16; (2) 45; (3) several hundreds. By 3 p.m. several hundreds had been discharged from (1) and (2).

Exper. 2. The dry material* was wetted at 11.15 a.m. on Feb. 13th and at 11.33 a.m. was placed in Petri dishes in the same positions as in *Exper.* 1. The number of ascospores *successively discharged*, and the variations of temperature, are shown in the following table (see p. 58).

The ascospores germinated normally after being kept for some hours in water.

The living ascus has the power of swelling and shrinking several times. If a current of a 2.5 or 5 per cent. solution of common salt is drawn through water in which there is an ascus which has swollen out as shown in Fig. 2, the ascus shrinks very rapidly, and the progressive thickening of the wall in consequence can be clearly seen under the microscope. (Cf. Figs. 7, 8, 9.) If distilled water is now added, the ascus at once begins to enlarge again, the cell-wall becoming thinner

* To secure as far as possible uniformity of the material as regards degree of maturity, every patch of mycelium (with its perithecia) taken from the shoots were divided into three portions, and one piece placed in each Petri dish. This was easy to do, as the patches were from 5 to 8 mm. long. The total size of the material placed in each Petri dish was 1 x .5 cm.

Experiment 2.

Time of examination.	1		2		3	
	Temp. ° C.	No. of spores.	Temp. ° C.	No. of spores.	Temp. ° C.	No. of spores.
Feb. 13, 12.30 p.m.	10	0	14	0	27	8
,, 1.0 ,,	10.5	0	14.5	0	27	15
,, 2.0 ,,	11	12	15.5	20	27	98
,, 2.30 ,,	10.5	30	15.5	42	27	34
,, 3.30 ,,	10	21	15	42	27	67
,, 4.30 ,,	9	15	15	110	27	20
,, 5.30 ,,	9	34	15	35	27	5
,, 9.0 ,,	10	over 200	15	over 100	27	30
Feb. 14, 9 a.m.	10—7*	bet. 500 & 600	15	about 200	27	0
,, 1 p.m.	12	about 200	17	8	27	10
,, 5 ,,	10	about 150	17	10	27	0
,, 10 ,,	11	18	17	0	27	0
Feb. 15, 9 a.m.	11—8.5	64	15	0	27	0
,, 2 p.m.	11	16	15	0	27	0
,, 9 ,,	7	0	15	0	27	0
Feb. 16, 9 a.m.	7—4	9	15	0	27	0
,, 9 p.m.	6.5	8	15	0	27	0
Feb. 17—18. Not observed	—	—	—	—	—	—
Feb. 19, 2 p.m.	***	about 30	15	0	27	0
,, 9 p.m.	6.5	8	15	0	27	0
Feb. 20, 9 a.m.	6.5—1	8	15	0	27	0
,, 9 p.m.	7.5	8	15	0	27	0
Feb. 21, 9 a.m.	9—5	8	15	0	27	0
,, 9 p.m.	9—4**	8	15	0	27	0
Feb. 22, 9 p.m.	—	16	15	0	27	0
Feb. 23, 9 a.m.	4.5—3	16	15	0	27	0
,, 9 p.m.	9—4.5	8	15	0	27	0
Feb. 24, 9 a.m.	6.5—-1	0	15	0	27	0
,, 9 p.m.	13—2	2	15	0	27	0
Feb. 25, 9 a.m.	4.5—3	0	15	0	27	0
,, 9 p.m.	12—2	3	15	0	27	0
Feb. 26, 9 a.m.	5.5—-1	0	15	0	27	0
,, 9 p.m.	9—0	0	15	0	27	0
Feb. 27, 9 a.m.	3.5—-1	0	15	0	27	0
,, 9 p.m.	15.5—-1	0	15	0	27	0
Feb. 28, 9 a.m.	5.5—0	0	15	0	27	0
,, 9 p.m.	13—3	8	15	0	27	0
March 1, 9 a.m	8—2	0	15	0	27	0
,, 9 p.m.	14.5—4.5	0	15	0	27	0
March 2, 9 a.m.	5.5—.5	16	15	0	27	0
,, 9 p.m.	—	0	15	0	27	0
March 3, 9 a.m.	5.5—0	0	15	0	27	0
,, 9 p.m.	10.5—2	6	15	0	27	0

* Maximum and minimum readings between 9 p.m. and 9 a.m.
** ,, ,, ,, ,, ,, 9 a.m. and 9 p.m.
*** The max. and min. readings between Feb. 16, 9 p.m. and Feb. 19, 2 p.m., was 10° C. —1° C.

and thinner, until the ascus attains its original volume. The process can be repeated several times, both with asci partly included in the perithecium and when free in the water.

In all cases observed the ripe ascus, *i.e.*, one capable of swelling up in water and discharging the spores, is (with the exception of the granular ascospores) hyaline (see Figs. 2, 4). During the process of the absorption of water, clear vacuole-like spaces arise round the ascospores (Fig. 6). These clear spaces vary in shape and size, and disappear and reappear when the ascus is made to shrink or swell.

A somewhat remarkable phenomenon has been observed under the following circumstances. If a living ripe ascus with hyaline protoplasm is given a certain amount of pressure——not sufficient to rupture the wall—a change is induced in the appearance of the protoplasm (epiplasm), which now becomes opaque and densely granular (and often somewhat vacuolate or " frothy ") so that the outline of the ascospores is nearly lost. (Cf. Figs. 10 and 11.) If the ascus at the time of treatment has swollen up in water, the pressure must apparently expel some fluid from the ascus, since its volume after the treatment is much smaller. The ascus is now, as far as I have observed, rendered incapable of swelling to the normal proportions and discharging its spores. If a solution of salt is now added, some amount of further shrinking takes place ; the granular substances ars dissolved very rapidly, and the ascospores are again visible, surrounded by the protoplasm as hyaline or almost as hyaline as before. If now distilled water is added, the hyaline protoplasm again becomes densely granular, this change taking place almost instantaneously. The process can be repeated many times. Experiments are now being made to ascertain the nature of these changes.

During 1913 the mildew was found beginning to develop the winter-stage as early as May 26th ; by June 6th the winter-stage was found in abundance well-developed on the berries of a number of varieties of gooseberries. The winter-stage may be formed almost at the beginning of an attack ; in one case (observed in a commercial plantation in Kent) the process of inoculation, incubation and the development of both the summer- and winter-stages occupied only eleven days.

THE "BROWN ROT" CANKER OF THE APPLE.

By E. S. Salmon.

In this *Journal* for 1910, the fact was pointed out that the fungus (*Sclerotinia* (or *Monilia*) *fructigena*) which causes the disease known as "Brown Rot" affecting the flowers and fruit of Plums, Cherries, Apples, Pears, Medlars and Peaches, is sometimes the cause of a definite "canker" in the branches of the Apple. Investigations showed that this "canker" injury may arise in two ways. Either the apples of the tree affected, when they are developing, are attacked by the "Brown Rot" fungus, with the result that the flesh of the apple becomes permeated by the spawn (*mycelium*), while pustules of spores (*conidia*) are produced on the outside. Many of these diseased and more or less rotten apples fall to the ground, but it is not uncommon to find some of them remaining on the tree, firmly attached to the spur or branch, throughout the winter right on to the following spring (see Plates IV. and V.). The apples which remain on the tree in this way are in a dried-up "mummified" condition; the spawn of the fungus, however, remains alive, and is capable, under suitable weather conditions, in the following year, of renewed growth, and the production of pustules of spores. In some cases diseased apples, when rotting under the attacks of the fungus, press against the part of the branch near the spur on which they are borne, and remain fixed for months in this position, the decaying flesh of the apple at first softening and then hardening, and, as it were, glueing the apple firmly to the branch. Under such conditions the spawn of the fungus grows from the diseased apple into the branch, and produces there a local

" canker "-like injury. In the following spring, or even during the winter if it is a mild season, pustules of spores are developed over the cankered area, breaking out through cracks in the bark from the underlying spawn. Sometimes the branch becomes completely girdled at the " canker," when of course the upper part of the branch dies ; this, however, rarely occurs in the case of large branches, but is frequent with the smaller twigs.

The second way in which the " Brown Rot canker " can arise on a branch is by the spawn of the fungus directly travelling into the wood from the fruit-spur, which has become diseased through its flowers or fruit having been attacked. The spur is killed, and the spawn travels from its base into the branch and forms there a " canker," from which the dead spur projects as a " snag " (see Plates VI. and VII.). In such cases the dead remains of the spur almost invariably bear numerous pustules of spores (see Plate VIII. and IX.).

During the past autumn and spring, outbreaks of Brown Rot on Apples have occurred to an unusual extent. In very many cases the attack has resulted in the formation of " canker " in the branches. As previously noted, the attack on the wood proceeds sometimes from the fruit and sometimes from the blossoms. Typical cases of the first method of attack were seen last autumn in several plantations near Maidstone. The variety was James Grieve ; a considerable number of the apples (which are soft-fleshed in this variety) were attacked just before ripening, and turned rotten. The spawn (*mycelium*) of the fungus invaded the cortical tissue of the spurs bearing such apples, and eventually entered the branch, soon producing in the part surrounding the spur a " cankered " area, where the bark cracked. In the cracks of the bark all over the " canker " pustules of spores were produced in abundance during the winter and spring. In some cases where a number of contiguous spurs were attacked, the " canker " resulting was as much as one foot in length, and from such a " canker " several dead spurs, showing where the fungus obtained an entrance, will project (see Plates X. and XI.).

More frequently, however, in the cases which have recently come under observation, the disease has commenced by the

fungus attacking the tree when in flower. A number—often a very large number—of flower-spurs are attacked, and then the fungus in the course of a few weeks enters the branch through the dead or dying spur. This kind of attack has taken place on a large scale in plantations of Cox's Orange Pippin and Lord Derby. The photographs at Plates XII. to XV. are of a branch of a tree of Cox's Orange Pippin, on which dozens of flower-spurs were attacked and killed; round the base of these spurs "cankers" arose, in the cracks of which pustules of *Monilia*-spores were freely produced in June. As these photographs, taken from each side of the branch, show, the canker has completely girdled the branch.

I am informed by Prof. H. H. Whetzel, Professor of Plant Pathology in Cornell University, U.S.A.,—to whom I recently showed some affected trees—that except for the occurrence of pustules of spores in the cracks, these injuries produced in the branch by the "Brown Rot" fungus, when it enters by the flower-spur as described above, are exactly similar to that caused by "Fire Blight" (*Bacillus amylovorus*)—an extremely destructive disease from which this country is at present fortunately free.

The varieties on which I have observed the "Brown Rot Canker" are as follows:—Cox's Orange Pippin, Lord Derby and James Grieve (all severely attacked): Worcester Pearmain, Ecklinville Seedling, Beauty of Bath, Ribston Pippin and Warner's King, less severely attacked.

With regard to remedies, where trees have been noticed to be affected in the previous season, all dead wood and cankers should be cut out, and the trees well sprayed with Bordeaux Mixture (4 lbs. quicklime, 4 lbs. copper sulphate, 50 gallons water), *just before* the flower-buds open. When the disease has been bad, a second spraying should be given *directly* the bloom has set, using Bordeaux Mixture or the lime-sulphur wash according to the variety of Apple. (The latter spray for Cox's Orange Pippin.) Where flower-spurs are observed to be attacked in the spring, I would strongly advise growers to cut them off immediately and burn them, as this measure *carried out in time* removes the disease before the fungus has time to grow into the branch. Besides the actual damage to the branches caused locally by the

formation of cankers, the cankered areas and the dead spurs projecting from them must be regarded as highly dangerous to the health not only of apple-trees, but of surrounding fruit-trees, such as Plums and Cherries, since pustules of spores are produced on them practically all the year round.

NOTES ON SOME FUNGOUS DISEASES.

By E. S. Salmon and H. Wormald.

1. A New Disease of Apple Buds.

In the last Report the occurrence of a new disease affecting apple buds was reported. The diseased apple-trees, growing at Chart Sutton, near Maidstone, were of the variety Grenadier and Bramley's Seedling, and in 1912 and 1913, some of the branches on the first named variety suffered to the extent of over fifty per cent. of the flower-buds being killed. In all cases microscopical examination showed the presence of the mycelium and spores of a fungus belonging to the genus *Fusarium*. For further details, and also for photographs of the diseased buds, reference may be made to last year's Report.

In April of the present year, Mr. H. B. Teagle, of Wisbech, Cambridgeshire, sent us for examination some diseased apple-buds; these proved to be infested with the mycelium of the same *Fusarium*. Mr. Teagle, who considers that the present disease is a serious one in the neighbourhood of Wisbech, and decidedly on the increase, sends the following information:—"We first noticed the disease here about three seasons ago, but only a small percentage of the buds were then attacked—the trees being of the variety Emneth Early. I may say here that the trees which I have noticed to be worse attacked are of the Codlin type, or soft wooded sorts. As far as I have observed, it is chiefly confined to the lower branches, and although we have had a comparatively dry season the last two years, and the trees have been winter-sprayed with lime and lime-sulphur solution, the disease has increased rapidly each year. After three years its effect is very apparent at a distance, causing the blossom buds to fail to develop, the lower branches having only a few blossoms on, and looking quite bare; some of the buds shrivel up and

remain on the tree, while others appear to fall. I do not think it affects the leaf buds, because I have noticed that when the flower-bud has fallen, the spurs shoot out about two leaf buds immediately at the side. The varieties which I have noticed to be affected this season are as follows :—

"Emneth Early. About 25 per cent. buds, lower branches.

"Worcester Pearmain. About 25 per cent. buds, lower branches.

"Lord Grosvenor. About 8 per cent. buds, lower branches.

"Lane's Prince Albert. About 8 per cent. buds, lower branches.

"Allington Pippin. A small percentage.

"Bramley's Seedling. A small percentage.

"In my experience Bramley's Seedling has only just begun to suffer from the disease."

In May, 1913, Professor B. T. P. Barker, Director of the Long Ashton Fruit and Cider Institute, announced the discovery of a bacterium which causes the blackening of pear blossoms, producing the injury commonly attributed to the action of frost or cold winds. In a more recent paper* on the subject, it is stated that there is reason to believe that a number of other plants are susceptible to attack. "A bacteriological examination of discoloured parts of flowers of apples, cherries, gooseberries and plums has been made, and in many cases there has been found in the diseased areas a bacillus in practically a pure state, which on isolation has proved to be the same organism as that occurring on the diseased pear flowers." "In the case of apples, discoloured flowers of Beauty of Bath, Bramley's Seedling, Allington Pippin, Devonshire Quarrenden, and Duchess of Oldenburgh have been examined, and from each sort the bacillus has been isolated."

It is mentioned that rarely other organisms appeared on the plate cultures, and in such cases the foreign form was nearly always *Monitia fructigena*, the "brown rot" fungus. It is not uncommon to find flowers attacked at the same time both by this fungus and the bacillus. No mention is made of the occurrence of a *Fusarium* in any of the material examined.

* "A Bacterial Disease of Fruit Blossom." By B. T. P. Barker and Otto Grove (Annals of Applied Biology, vol. I., p. 85, 1914).

Some of the apple-buds sent by Mr. Teagle were submitted for examination to Professor Barker, who reported: "Mr. Grove has examined the buds which you sent, and has obtained very numerous colonies of our Fruit Blossom Bacillus from them, in addition to your *Fusarium*. At present I am not sure how much of the damage is to be attributed to *Fusarium*, and how much to Fruit Blossom Bacillus. Very possibly, since the latter appears to be very widely spread, and has been found by us on perfectly healthy parts of plants, the *Fusarium* may be the actual cause of all the trouble, and the presence of the bacillus accidental."

In our first account of this disease on apple-buds we wrote: "In a few cases bacteria have been observed in the gummy fluid which often oozes from the brown dead cells of the bud-scales when placed in water." Future investigations will decide as to whether the *Fusarium* or the bacillus is the primary cause of the death of the apple bud.

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2. Celery "Blight."—(*Septoria Petroselini* var. *Apii*.)

In the account given in the last Report of the now very prevalent disease of Celery, known as "Blight" or "Rust," we wrote: "The disease is usually present on celery plants quite early in the season, and—just as with potato 'blight'—if the grower waits until late in the season before taking remedies, the case is hopeless. The erroneous idea of its late appearance on the plant has probably arisen from the fact that the evident 'wilting' and death of the leaves does not take place usually until July or later, although an examination of the plants in June will generally show the presence of the fungus on many of the leaves." Photographs were given from a seedling celery plant, showing that the disease may be present on these as early as the first week of May. For the life-history of the fungus which causes Celery "blight," and for the remedies which have proved successful in dealing with the disease, reference may be made to the Report; the purpose of this note is to call attention to the fact that Celery *seed* may be infested with the fruit-conceptacles (*pycnidia*) of the fungus *Septoria* which causes the "blight." In such cases as the photo-micrograph at Plate XVI. shows, little black "dots"—the fruit-conceptacles (*pycnidia*) of the fungus—can

be seen (using a pocket magnifying-glass) on the surface of the seed or of the piece of stalk attached to them. It is probable that the sowing of seed bearing the fungus is the principal means by which the disease is distributed. When such seed is planted, outbreaks of the disease *in the seed-bed* may be expected to occur. It would probably be a good plan, when the disease is noticed on the seedling plants, to dip them in Bordeaux mixture at the time of transplanting them to the trench.

Last Spring commercial samples of seed* of the following varieties were found to be infested with fruit-conceptacles (containing *spores*) of the fungus : Solid White, Sandringham Dwarf White, Clark's Extra Early Market—all badly infested ; also on Sutton's White Gem, and Bibby's Defiance White.

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3. **The White Root Rot.**—(*Dematophora necatrix* Hedw. *Rosellinia necatrix*, Prill. and Del.)

In January last we received the following communication from a fruit-grower near Canterbury : " We are sending you an Apple tree, with some of the soil attached, taken up from our plantation at Harbledown, for examination. There are several patches of a rod or so each, in this plantation, from which we have grubbed old Cherry trees, and on which we can get neither bushes or trees to live since the grubbing. The tree we are sending you is a Lord Derby, and we have had Beauty of Bath, and Bramley's Seedling, and also Gooseberry bushes die after a year or so, on the same patches. We shall be glad if you can give us any information as to the cause of the trees and bushes dying, and whether you can suggest any special treatment of the soil to prevent the same."

The examination of the tree sent revealed the presence on the surface of the roots of strands of white matted mycelium (see Plate XVII.). Under the microscope the threads (*hyphæ*) of this mycelium showed the characteristic structure of those of the White Root Rot Fungus, *Dematophora necatrix* Hedw. (see Fig 1). Under certain circumstances this fungus is very destructive to fruit trees and bushes ; a visit was therefore paid to the farm to ascertain the local conditions.

* Samples of Celery seed suspected of carrying the disease may be sent to the College for examination free of charge.

The piece of ground affected was between two and three acres in extent. A number of old Cherry trees growing on it had been grubbed up several years ago, many of the deeper roots being left in the ground. Apples and Gooseberry bushes were then planted, and the presence of the disease became noticeable through the death season after season of some of the young Apple trees and also of the Gooseberry bushes. Apple trees were re-planted from time

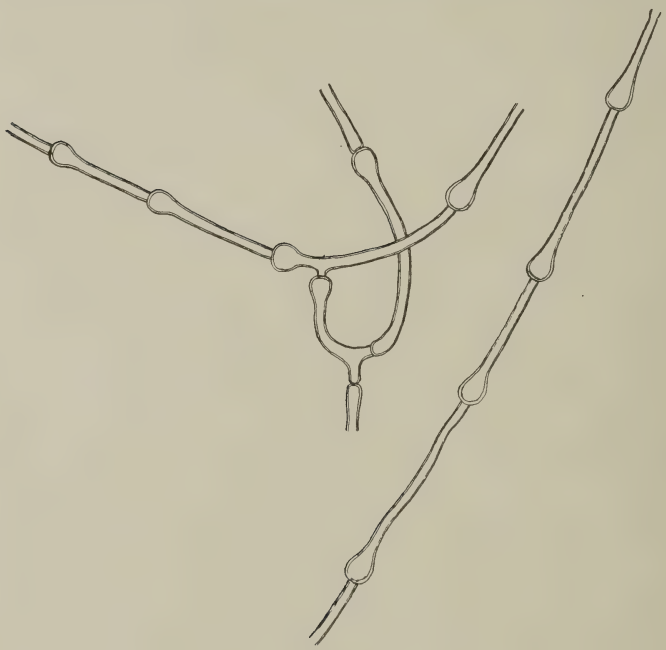

Fig. 1.

to time, but finally the remaining Gooseberry bushes (" Yellow Rough ") over the whole piece were grubbed up. This process was accomplished by attaching a chain to the bush and dragging it out, an operation which necessarily left in the ground a considerable number of the roots. In digging the ground from time to time portions of these old Gooseberry roots were brought to the surface, and at our visit we noticed several on the surface of the soil, or

protruding from it. On such roots the mycelial strands occurred in profusion, and subsequent microscopical examination showed that they were those of the White Root Rot Fungus. There was clear evidence, therefore, that this fungus was persisting in the ground on the old roots of the Gooseberry bushes, and from these attacking the young Apple trees as they were planted. The plantation was dug by piece work, and consequently no efforts had been made to clear the ground of old roots. Following the advice given, the treatment of the plantation in the future will be as follows :—Trenching of the ground, with the collection and burning of all old roots, and the necessary subsequent diggings (not by piece work), attention always being paid to the removal, as far as possible, of old roots. It is only by such measures that ground once infested can be cleared from a root parasite such as the present fungus.

The Board of Agriculture on June 18th, 1908, by their "Destructive Insects and Pests Order of 1908" made the White Root Rot a notifiable disease. This was an ill-advised step, since the present disease is neither a new disease nor one highly infectious. The Board have since realized their mistake, and we find that in their more recent Order, the White Root Rot is omitted from the list of diseases which the fruit-grower is now required by law to notify.

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4. Leaf Spot of Cabbage and Broccoli.—*Mycosphaerella brassicicola* (Duby) Lindau.

This fungus, frequently found during the winter months on leaves of species of *Brassica* (see Plate XVIII.), is considered to be the "perfect stage" of a conidial form *Phyllosticta Brassicæ* which causes a "leaf-spot" on Cabbage, Broccoli and allied plants. Dr. M. C. Cook in his "Fungoid Pests of Cultivated Plants" says of this fungus :—"The mature stage of this pest, in the form of *Sphærella*, is not reached until the leaves have lain some time on the ground."

Observations made at this College during February and March, 1914, show that this statement requires modification, for in some cases the *Sphaerella* (or *Mycosphaerella*) stage with mature ascospores has been found on living green leaves of Cabbage and Broccoli. On one occasion,

while an examination of the fruit bodies was being made under the microscope the asci were seen to elongate and eject the ascospores. The spores as shown in Fig. 2 are two-celled, spindle-shaped (*fusiform*), with rounded ends, usually slightly curved and with a slight constriction at the septum ; the septum is medial, but as a rule one cell is slightly broader than the other.

They are usually thrown out in rapid succession, though sometimes a few seconds elapse between the ejection of one spore and that of the next. While the process was under observation, one spore was caught at the middle where the constriction occurs, by the partial closing of the pore of the ascus, so that one of the two cells of the spore was outside and the other inside the ascus ; it remained in that position for a short time but was eventually ejected.

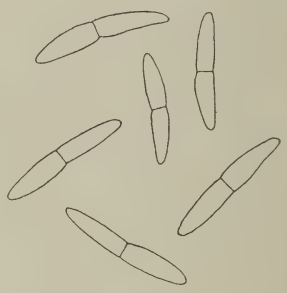


Fig. 2.
Ascospores of *Mycosphaerella brassicicola* × 650.

Green leaves of Broccoli, with the mature stage of the fungus have been sent in from Clapham, near Worthing, and from Handcross, Sussex. Our correspondent from Handcross writes : " I enclose some specimens of Broccoli leaves (variety, Late Queen). The 'spot' appears in autumn and increases in extent during winter, attacking all but the younger leaves of most of the *Brassicas* we grow ; I have not noticed it on Turnips. The disease is very prevalent all over this neighbourhood, especially in the allotments."

Living leaves of Broccoli and Cabbage obtained from the College gardens were also found to have the *Mycosphaerella* stage (with mature spores) on the diseased spots.

A HEART ROT OF CELERY CAUSED BY BACTERIA.

By H. Wormald, A.R.C.Sc., D.I.C., B. Sc.

During the summer and autumn of 1912 the celery crop in the gardens connected with this College was attacked by *Septoria Petroselini* var. *Apii*, the fungus causing the Celery Leaf Blight.* Towards the end of the season, viz., in the months of January and February, this fungus occurred not only on the upper green portions (laminæ) of the leaves but also on the bleached leaf-stalks where numerous *pycnidia* (the fructifications containing the reproductive bodies) were to be found. Leaves attacked by the *Septoria* only, usually assume, sooner or later, a wilted and withered appearance; some of those which came under observation, however, were quite soft and of a pulpy or gelatinous consistency, dark brown in colour and glistening on the surface. A particle of such material when subjected to microscopic examination was found to be swarming with actively motile rod-shaped bacteria.

It was at first thought that the bacteria were living saprophytically on the tissues primarily killed by the *Septoria*, for this fungus is known to produce a rot of celery, particularly if, after they are lifted, the plants are stored for some time before being used, as is a common custom in America. When, however, a little of the pulp was removed from the region bordering on the living tissue and examined, bacteria alone were found, there being no trace of either pycnidia or fungal hyphæ. It seemed certain, therefore, that the bacteria to be found in such a region were not living on tissues which had previously been killed by some other organism, but that they were actually attacking the living cells and were the primary cause of the decay. In all probability, when the tissues are killed saprophytic bacteria do gain an entrance and accelerate the process of decay, for although one form (and possibly a second) has been isolated which is capable of attacking

* *See* Vol. XXI., pp. 329-338, for description of this disease.

living celery plants, others have also been isolated from similar material which apparently have no power to attack the living plants even when introduced through a wound.

That bacteria are able to produce disease in plants was first demonstrated less than forty years ago. About 1880 plant pathologists began to suspect that certain bacteria were pathogenic in plant tissues and that they could, under favourable circumstances, behave as virulent parasites. Particularly interesting in this connection was the work of Burrill (2)*, who showed that the Pear Blight or Fire Blight, a disease which is very destructive to pear trees in America and which had long puzzled growers and investigators in that country, was to be attributed to bacterial action. At first the idea that bacteria could, unaided by other organisms, cause maladies in healthy plants, was considered by many as highly improbable, and even as recent as 1897 we find a prominent German investigator, Dr. Alfred Fischer (4) of Leipzig, maintaining that bacteria were unable to attack vegetable cells, even assuming that they came in contact with the more delicate internal tissues by gaining entrance through the stomata or by being introduced through a wound. Those statements were ably criticized by Dr. E. F. Smith (11), Plant Pathlogist to the Department of Agriculture in the United States, who was able to prove conclusively in papers published in 1899 and 1901 that bacteria could independently produce disease in plants. Since the latter date bacteriosis of plants has been generally accepted as an established fact; not only have the results of the pioneers in this field of work been confirmed and amplified, but many other bacteria which have been proved capable of inducing pathological conditions in plants have been isolated and described, and the number of such forms is increasing year by year. The bacteria are probably unable to penetrate surfaces protected by cuticle or layers of cork, but they may gain access to the interior not only through wounds, but also, in some cases, through the natural pores (the stomata and water-pores) or at unprotected surfaces as in nectaries.

The abnormal results brought about by these parasites are various, depending on the mode of parasitism of the

* The numbers refer to the Biography on pp. 86-87.

organism and the behaviour of the host plant, but in this country, and probably abroad, the most troublesome forms appear to be those which induce a " soft-rot " in the organs invaded. The final result is practically the same in all cases of soft rot ; the tissues are reduced to a pulp and often the rot progresses until the whole of the plant attacked is reduced to a soft, moist, fetid mass. This type of bacteriosis includes the celery-rot observed at Wye.

Very little work appears to have been done hitherto on bacterial rots of celery and apparently only one observer has previously isolated and described a bacterium from this plant. This investigator was Brizi (1) who in 1896 described a celery-rot in Italy, and from the material obtained a form which he named *Bacterium Apii* [=*Bacillus Apii* (Brizi) Migula]. The disease, which at that time was causing considerable damage in that country, bore some resemblance, as Brizi pointed out, to a similar rot recorded from New Jersey, U.S.A., by Halsted in 1892. The American organism was not described in Halsted's account of the disease.

The more important works dealing generally with fungous diseases of plants, if they mention the celery at all in this connection, supply only brief references to the work of Halsted and Brizi, as in Sorauer's *Handbuch* (13) and in a recent volume by Ferraris (3).

Outbreaks similar to those mentioned above have been observed in other countries as shown by Ritzema-Bos (10), who in 1905 isolated a bacterium from celery and reproduced the rot by inoculation but did not describe the organism, and by Johnson and Adams (8) who noticed in celery " a brownish-rot similar to that of cabbage " in Ireland in 1910.

Professor Priestley,* of the University, Leeds, informs me that a celery-rot was observed in October, 1910, near Bristol. Apart from this I have not been able to obtain any evidence that the disease has been met with in this country except in the two instances mentioned below, which, however, together with the records from Bristol and Ireland, suggest that the rot may be fairly wide-spread.

A short time ago a gardener at Guildford, Surrey, to whom a diseased specimen from Wye had been shown, stated that

* Formerly of Bristol University.

he had lost a whole row (thirty yards long) and that the plants became "a sort of jelly" as he aptly expressed it. This jelly-like appearance is quite typical of the bacterial rot.

The *Gardeners' Chronicle* for October 18th, 1913, recorded that celery affected by bacteriosis had been sent in by a correspondent. The editors kindly put me in communication with the grower, who gives me this information: "Our celery was attacked in September; at first a few blotches were noticed, and then in one day the whole plant rotted down to the earth. Our man had to dig up and burn some and the rest he cut off; this eventually grew again a little, and we were able to use it. As far as I can hear, all this neighbourhood (Writtle, Essex) has been attacked in the same way." In this case, the early appearance (*i.e.*, September) of the disease is remarkable. The outbreak observed by Professor Priestley in Gloucestershire was also early in the season, while at Wye it has not been noticed before February 1st, on which date the first diseased specimen was examined in 1913.

The material that has come under my own personal observations has all been obtained from the College gardens at Wye. In some of those plants the outer leaves* only were attacked and for culinary purposes such samples suffered little or no depreciation in value; in the majority, however, the inner leaves were in a more or less advanced stage of decay, and at least some portions of these had to be removed, whilst in others all the inner leaves were destroyed and the rot had extended into the stem itself, destroying this from above downwards. In a few cases leaf-stalks which appeared normal on the surface showed, on being split longitudinally, discoloured internal tissue swarming with bacteria. Diseased plants often showed wounds caused by snails or slugs, and the inner surface of many of the petioles was transversely wrinkled; this latter condition is not always accompanied by a bacterial rot, though it seems to favour the development of the organisms since they are frequently to be found beneath the ridges. Eelworms were sometimes found in considerable numbers in the decaying parts, and it is probable that they, as well as snails and slugs, aid in disseminating the bacteria.

* "The outer leaves" are here understood to be those which even in normal plants would be discarded and stripped off before "the inner leaves" are prepared for the table.

The disease appeared again in the College gardens on February 11th of the present year (1914), and in order to obtain some idea as to the amount of damage done it was arranged that as the plants were removed from the ground for use they should be brought into the laboratory so that the plants could be subjected to individual examination. From February 18th until March 22nd, 108 plants of the variety " Standard Bearer " were examined ; the results are given below. The other varieties grown in the gardens had been lifted before February, and the disease had not been observed on those. The following points were considered :—

(1) Whether the plants showed merely a normal decay or whether they suffered from soft-rot ;

(2) whether the rot occurred in the outer leaves only, on the inner leaves only, or on both ;

(3) whether the attack was a slight or a serious one ; a slight attack was taken as being one where from one to three only of the inner leaves showed the rot, and a serious attack as one in which there were more than three such leaves.

	On outer leaves only.	On inner leaves only.		On inner and outer.		Normal decay only.	Number of plants examined.
		slight.	serious.	slight.	serious.		
Feb. 18th. ..	—	2	1*	—	—	—	3
,, 20th ..	—	2	—	—	—	—	2
,, 21st ..	2	3	1*	2	—	2	10
,, 23rd ..	1	2	1	4	—	—	8
,, 25th ..	3	2	—	2	—	1	8
,, 26th ..	—	2	—	2	1	—	5
,, 27th ..	—	—	1	3	—	—	4
,, 28th ..	—	1	1	3	3	—	8
Mar. 2nd ..	1	—	—	2	—	1	4
,, 3rd ..	2	2	—	2	—	—	6
,, 7th ..	—	—	1*	—	—	—	1
,, 10th ..	—	1	1	1	—	1	4
,, 12th ..	—	1	3†	—	—	1	5
,, 14th ..	1	1	—	4	—	2	8
,, 16th ..	1	1	1	1	1	1	6
,, 17th ..	—	1	2	—	—	—	3
,, 18th ..	1	3	1	—	—	2	7
,, 19th ..	1	1	1	—	1	4	8
,, 22nd ..	—	2	—	4	—	2	8
Totals ..	13	27	15	30	6	17	108

* The centre of each of these plants was almost destroyed.

† Two of these three were altogether useless.

From these figures it will be seen that out of 108 plants 78 (approximately 72 per cent.) had inner leaves affected, while 21 (about 19 per cent.) were almost, if not quite, worthless.

The pulpy, brown, diseased portions of these inner leaves were readily distinguished from the healthy tissues, the discolouration of the former contrasting strongly with the adjoining blanched parts as shown in Plate XIX. In the older outer leaves the difference was not so marked.

Celery is not usually stored for any great length of time in this country and, as a rule, only when there is the possibility of the ground becoming so frozen that plants cannot be lifted for some days, in which case a quantity sufficient to last several days is taken up and kept until required. Under these circumstances the figures in columns 2 and 4 (slight attacks) are not so formidable as at first sight they may appear, for if, as in this instance, such plants are used immediately, the greater part of each would be in good condition; if stored these plants would undoubtedly become destroyed in a very short time, judging from the rate of progress of the rot in those plants inoculated from pure cultures and from naturally infected specimens kept in the laboratory.

As an illustration of the procedure in isolating pathogenic and other bacteria, the "poured-plate" method adopted for isolating the celery organism is given below:—

A nutrient medium* consisting of 1.5 per cent. agar-agar in an extract prepared from celery stems or leaf-stalks was found to be suitable for rapidly obtaining cultures of the bacterium. About 10 cc. of this medium were poured while hot into each of a number of test-tubes, which were then plugged with cotton-wool and sterilized either by steaming at 100°c. for twenty minutes on each of three successive days (discontinuous sterilization), or by steaming under pressure (in an autoclave) at 115° c. for twenty minutes once only. Such tubes after cooling were stored until required. When suitable (rotting) celery material was obtained, three of these tubes were steamed to melt the agar and allowed to cool in a beaker

* The method of preparing this medium is given in detail as a footnote in the Journal of Agricultural Science, Vol. VI., Part 2, May, 1914, p. 212.

of warm water until the temperature of the beaker and its contents dropped to 44° c.* A small particle of the bacteria-containing pulp taken from near the junction of diseased and healthy tissue was placed in a drop of sterile water on a flamed slide; almost immediately innumerable bacteria diffused out into the water and a small drop was then transferred to tube No. 1 by means of a platinum wire loop which had previously been flamed and allowed to cool. A drop of the liquid from tube No. 1 was taken on the platinum wire and transferred to tube No. 2; similarly a drop from No. 2 was placed in No. 3. The contents of each tube, after being thus inoculated, were poured into a sterile petri dish and allowed to cool until the agar had solidified in a layer covering the bottom of the dish, which was then placed in an incubator at 26°c. In this way the bacteria became separated from one another, and each by rapid division gave rise to a colony. An examination of the plates made at the end of twenty-four hours showed No. 1 to be densely crowded with very small colonies; in No. 2 the colonies were less numerous, while in No. 3 they were well separated from each other although the colonies themselves were larger than in the other two plates.

From one of the isolated colonies so obtained a tube culture was prepared by taking a small portion of a colony on a platinum wire and drawing the needle over the surface of agar in a test-tube. Such a tube culture, the product of a single bacterium, is consequently *pure* and may be used in preparing "sub-cultures" and in performing inoculation experiments.

An organism which was isolated in this way from diseased celery proved capable of reproducing the rot when inoculated into healthy celery plants. Preliminary experiments were made by inoculating fresh pieces of celery "heart" (see Plate XX., No. 2), while subsequent inoculations were made on living plants. Of the latter some were taken direct from the garden, and, after the outer leaves were stripped off, the remaining central portion (stem and inner leaves) of each with roots still attached was washed under the tap, then with sterilized water, and the roots placed in a beaker of water, the whole being

* Agar solidifies at about 42° c. and the "plating out" must be done while the agar is at a temperature above 42° c., but not so high as to kill the bacteria.

covered with a bell-jar to minimize infection from air-borne spores; other plants used in the experiments were grown in pots in ordinary soil.

The bacterium was introduced into the tissues by placing a small portion of a culture on the cut ends of the petioles or in wounds made on the inner surface of the petioles.

One of these plants used in the inoculation experiments is shown in Plate XXI.; it was kept in a fresh condition during the experiment by placing the roots in water. The two largest leaves appearing in the photograph were wounded on the inner side of the leaf-stalk, at about one inch below the insertion of the lowest pair of leaflets, by the removal (using a flamed scalpel) of a small portion of tissue towards the upper surface, leaving a wound about one-eighth of an inch in diameter (in imitation of those made by snails and slugs), and penetrating about half-way through the petiole. Bacteria, taken from a single colony of a poured plate culture twenty-four hours old, were placed in the wound made in the leaf on the left, while that on the right remained without further treatment after the wound had been made. On the following day (twenty-four hours after inoculation) the infected leaf showed a brown area 1.8 cm. long and 0.9 cm. broad round the wound, from which was oozing a drop of liquid swarming with actively moving bacteria; the control leaf was unchanged. After a further period of twenty-four hours the discolouration (indicating extent of the soft rot) had reached to the edge of the petiole on both sides so that there was a zone of rotten tissue across the whole width and in consequence of this that portion of the leaf above the zone collapsed. This stage is shown in the photograph, the control remaining still unchanged. A fortnight later the rot had extended to the base of the inoculated leaf and was encroaching on the rest of the plant.

The plants growing in pots were also inoculated on the petioles, but in these cases the bacteria were placed on the inner surface and pricks were then made with a sterile needle through the bacterial mass. At first several pricks were made in each petiole to ensure a successful contact between the bacteria and the internal cells, but later it was found that a *single prick* made through a mass of bacteria taken from a young culture was sufficient to start the rot. In one

experiment, using a plant growing in soil, two petioles were inoculated by means of a single prick with a needle, with the result that on the third morning after the inoculation was made it was found that one of them had collapsed during the night, and that the rot had extended to 1 cm. above and 3 cm. below the point where the bacteria had been introduced; a few hours later the second leaf also collapsed and in this instance the limits of the rot were 1 cm. above and 2 cm. below the point of inoculation.

Whether the disease is contagious in the case of uninjured plants has not yet been definitely determined. In one experiment, however, it was noticed that where diseased leaves had collapsed and fallen across healthy ones the latter acquired the rot, which commenced in the neighbourhood of the spots where the remains of the decayed leaves had lodged. It is conceivable that the weight of the decaying mass might, in some instances, fracture the stalks of the leaflets and so permit the bacteria to enter through the wounds, the celery plant, particularly the young leaves, being very brittle.

Inoculation experiments performed last year (1913) on seedling celery plants a few inches high were only partially successful, and similar experiments are being carried out this year.

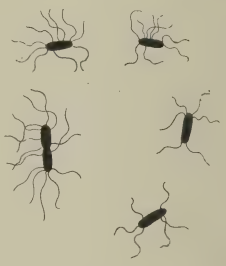
The organism, identified as described below, has been re-isolated from tissue which have become diseased after artificial infection with a pure culture, thus substantiating the evidence (already obtained by reserving, at the time the inoculations were made, corresponding controls* which did not contract the rot) which shows that the organism introduced into the plant was the one which produced the symptoms of the disease.

The bacteria parasitic in plant tissues are, with very few exceptions, to be referred to two genera comprising those rod-shaped forms which under favourable circumstances exhibit motility when in liquids; the movements are performed by means of wavy-bent processes of the protoplasm. These whip-like processes, or *flagella*, in the two genera are either scattered over the whole surface of the bacterium (genus

* The "controls" were plants, or petioles of the same plant, which were wounded like those inoculated, but bacteria were not applied to the wounds.

Bacillus Cohn) or are situated only at one "pole" (genus *Pseudomonas* Migula). The presence and arrangement of the flagella can be demonstrated only by special methods of staining, which usually involve the use of a "mordant." The figure shown on this page was drawn from a preparation stained by what is known as "Moore's Pitfield" method.

The species within the genus are, as a rule, indistinguishable morphologically, for bacteria, being unicellular organisms, do not possess "organs" or other characteristic features (except flagella) which might furnish means for description; size and shape are by no means constant, but often vary considerably even in cultures derived from the same individual. Identification therefore depends chiefly on their physical reactions, that is their behaviour under varying external factors as changes in nutrition, in temperature, etc. Their cultural relations are of primary importance and every species investigated must be cultivated on various recognized media before an adequate description of the organism can be obtained.



Bacillus apiovorus × 1,200.

Innumerable culture media, some of which are of general application, others that are used for special purposes, have been devised and new formulæ are still being published. Until a few years ago there was no defined system for the employment of these media and it was often difficult to obtain comparative results.

In recent years bacteriologists, particularly in America, have endeavoured to obviate this difficulty by introducing a basis of classification by means of which "the salient features of an organism belonging to any one genus can be conveniently expressed by a series of digits, representing a whole member and a decimal."* The system has been elaborated by the Society of American Bacteriologists and a description of it is given in a bulletin by Harding (6) published 1910. The method has been adopted by Dr. Erwin F. Smith (12) who is

* Quotation from the "Preliminary Report of the Committee on Methods for Identification of Bacterial Species," prepared for the Society of American Bacteriologists.

probably the greatest present-day authority on bacteriosis in plants and is used by him in his monograph on that subject, three volumes of which have already appeared.

The "Numerical System of Recording the Salient Characters of an Organism" is as follows :—

100.	Endospores produced.
200.	Endospores not produced.
10.	Aërobic (strict).
20.	Facultative anaërobic.
30.	Anaërobic (strict).
1.	Gelatin liquefied.
2.	Gelatin not liquefied.
0.1	Acid and gas from dextrose.
0.2	Acid without gas from dextrose.
0.3	No acid from dextrose.
0.4	No growth with dextrose.
.01	Acid and gas from lactose.
.02	Acid without gas from lactose.
.03	No acid from lactose.
.04	No growth with lactose.
.001	Acid and gas from saccharose.
.002	Acid without gas from saccharose.
.003	No acid from saccharose.
.004	No growth with saccharose.
.0001	Nitrates reduced with evolution of gas.
.0002	Nitrates not reduced.
.0003	Nitrates reduced without gas formation.
.00001	Fluorescent.
.00002	Violet chromogens.
.00003	Blue chromogens.
.00004	Green chromogens.
.00005	Yellow chromogens.
.00006	Orange chromogens.
.00007	Red chromogens.
.00008	Brown chromogens.
.00009	Pink chromogens.
.00000	Non-chromogenic.
.000001	Diastasic action on potato starch (strong).
.000002	Diastasic action on potato starch (feeble).
.000003	Diastasic action on potato starch (absent).
.0000001	Acid and gas from glycerin.
.0000002	Acid without gas from glycerin.
.0000003	No acid from glycerin.
.0000004	No growth with glycerin.

When the organism isolated from celery had been shown, by the experiments to which reference has already been made, to be pathogenic to living celery plants, it was decided to obtain a description of it in accordance with the above scheme. It proved to be a *Bacillus*, motile by means of from two to twelve flagella. When obtained from the celery pulp or from young cultures (twenty-four hours old), the rods measure 2.5 — 3.5 × 0.6—0.7μ if occurring singly. Sometimes double rods (dimensions 5—6.5 × 0.6—0.7μ) are met with, *i.e.*, two rods joined end to end and formed by the transverse fission of a single one the two individuals not having separated from each other; less frequently rods representing four bacteria are found.

Endospores have not been observed. The organism is aërobic, that is, it prefers to live in contact with air, but it is not strictly so, since it will grow readily in the closed end of a fermentation tube filled with a suitable nutritive liquid (facultative anaërobe). Gelatin (ten per cent. in beef bouillon)* is quickly liquefied; the culture shown in Plate XXII., Nos. 2 and 3, was obtained by making a *stab* with an inoculated platinum needle in the gelatin contained in the tube. As the bacteria began to multiply they induced a liquefaction of that medium, an early stage of the process being shown in the first of the two photographs and the completion in the second.

The dextrose solution consisted of :—

Peptone	2 gm.
Dextrose	1 gm.
Distilled water	95 cc.
Litmus (neutral) solution	5 cc.

By substituting lactose and saccharose respectively in place of the dextrose the media containing those sugars were prepared similarly. The solutions were poured into Durham's tubes† (15 cc. in each) and steamed for twenty minutes on

* Nutrient bouillon, a medium very frequently used for bacterial cultures, is a meat extract preferably prepared from fresh lean beef.

† A Durham's tube consists of a test-tube with a smaller tube, mouth downwards, placed inside; the intermittent steaming removes the air from the smaller tube, which consequently becomes filled with the liquid; on inoculation with a gas-producing organism bubbles of gas accumulate at the upper (closed) end of the smaller tube.

each of three successive days. Tubes were inoculated and incubated at a temperature of 26° c. ; after twenty-four hours the solutions had become turbid and the original neutral tint of the liquid showed a reddening which was quite distinct in the tubes containing dextrose and saccharose, less so in those with lactose, though after a further period of twenty-four hours the red tint (indicative of acid formation) was equally evident in all three. Small bubbles of gas began to appear about this time, but gas production was never very copious and usually ceased after about two days. Control tubes, incubated at the same time, but not inoculated, showed no change whatever to the end of the experiment. The same three media were used for cultures in fermentation tubes, and the results, *i.e.*, turbidity, colour changes, and gas production, were similar to those in Durham's tubes.

The action on nitrates was studied by preparing tubes of a 0.5 per cent solution of potassium nitrate in nutrient bouillon. Ordinary tubes and Durham's tubes were used and inoculation made but no gas could ever be detected in the latter. After a few days, tests for nitrites were applied with very distinct positive results (negative results with the controls.) The result shows that potassium nitrate, in a nutrient medium inoculated with the bacillus, is reduced to nitrite without the evolution of gas.

Most of the cultures have a faint yellow tint but the colour is much more pronounced when sterilized potato is used as the nutrient medium.

Diastasic action on potato starch is estimated in accordance with the reactions given by the potato after the bacillus has been growing on it for some time and those given by inoculated tubes of starch jelly. The latter medium was prepared by rubbing up potato starch in Uschinsky's solution, modified and recommended for this purpose by Dr. Smith.* The results obtained indicated that the organism has but a very feeble action on the starch, no trace of sugar being found in any of these cultures, although a purplish reaction with iodine suggested the change of some of the starch to dextrin.

Glycerin cultures were obtained in Uschinsky's solution

* Bacteria in Relation to Plant Disease. Vol. I., p. 196.

containing four per cent. glycerin according to the following formula :—

Glycerin	40 cc.
Sodium chloride	6.0 gm.
Calcium chloride	0.1 gm.
Magnesium sulphate	0.4 gm.
Dipotassium phosphate	2.0 gm.
Ammonium lactate	6.0 gm.
Sodium asparaginate	4.0 gm.
Distilled water	One litre.

Ordinary tubes and Durham's tubes were used ; no gas was produced in the latter and tests were made for acid production but with negative results even in cultures fifteen days old, although a turbidity, resulting eventually in a dense sediment, showed that vigorous growth had occurred in the tubes. Control tubes remained quite clear. The inference is that in a suitable medium containing glycerin the organism is able to thrive but cannot convert the glycerin into acid.

After these cultural characters had been determined the organism was inoculated into a living plant, and when the rot had become established the bacterium was re-isolated. The new strain also proved to be a *Bacillus*, and in pure cultures gave results similar to those set out above, thus indicating that the two strains were identical. The conclusion to be drawn is that the organism with the characters set out in the following table and arranged according to the scheme set out on p. 81 is parasitic in celery plants and produces a soft rot :—

Endospores not produced	200.
Facultative anaërobic	20.
Gelatin liquefied	1.
Acid and gas from dextrose	0.1
Acid and gas from lactose	.01
Acid and gas from saccharose	.001
Nitrates reduced without gas formation	.0003
Yellow chromogens	.00005
Distasic action of potato starch (feeble)	.000002
No acid from glycerin	.0000003

The group number of this *Bacillus* thus becomes 221.1113523.

A more detailed account of the cultural reactions and of the inoculation experiments performed on celery may be seen in a paper by the writer (14) appearing in the *Journal of Agricultural Science*, May, 1914.

The organism appears to be one that has not previously been described and it is proposed therefore to name it *Bacillus apiovorus*. It seems clear that it is not the form described by Brizi for he states emphatically that his bacterium does not liquefy gelatin, while *Bacillus apiovorus* induces liquefaction very readily. On the other hand, the group number of the latter approaches that obtained for *Bacillus carotovorus* Jones, described and named by Jones (9) in 1901, and more recently investigated by Harding and Morse (7). The form number of *Bacillus carotovorus*, which also causes a soft-rot and is very destructive to carrots and other vegetables, is 221.1113022 ; a reference to the table on p. 81 will show that it is a white organism (*i.e.* non-chromogenic) which produces an acid in a glycerin-containing medium. Since the earlier cultural experiments were performed the absence of acid production from glycerin in the case of the *Bacillus* isolated at Wye has been confirmed by cultures and tests carried out in collaboration with the Chemical Research Department at this College.

Harding and Morse point out in their paper that there is a group of closely related forms (of which *Bacillus carotovorus* may be taken as the type) that produce soft-rot in vegetables, and *Bacillus apiovorus* must be included in that group.

It is probable that several bacteria are concerned in producing bacteriosis in celery. In addition to the *Bacillus* described above, a *Pseudomonas* with 1-3 flagella at one pole has been isolated and reproduced the symptoms of the rot on being placed on fresh slices of celery " heart," but so far as experiments have gone it is not certain that it can attack growing plants. Then, again, there is the form *Bacillus Apii* obtained by Brizi in Italy, but which has not yet been reported from this country.

Professor Saccardo informs us that bacterial rot of celery has again been prevalent in Italy during the past season, and Dr. M. T. Cook, the Plant Pathologist at the New Jersey Agricultural Experiment Station, writes to the effect that it has recently re-appeared near that station. The disease has been

noticed, as shown in this paper, not only in Kent, but in Essex, Gloucestershire, probably Surrey, and in counties Derry and Tyrone, Ireland. Although the available evidence does not show that the celery soft-rot is responsible for any considerable loss in this country, the observations made by Halsted in America and Brizi in Italy indicate that bacteria may seriously injure the celery crop, and growers are advised to take precautionary measures if symptoms denoting a bacterial rot come under their notice.

The only treatment that can at present be recommended is the destruction of diseased plants by burning to prevent inoculation of the soil; on no account should such plants be thrown on the manure heap, for the bacillus is able to live saprophytically some months and still retain its destructive properties. For the same reason, if the crop becomes infected, celery should not be grown on the same plot in the succeeding season.

Any measures taken to prevent attacks by snail, slugs, eelworms, and biting insects will tend to check the spread of the disease.

In conclusion the writer desires to thank Dr. Eyre and Mr. E. A. Fisher, B.A., of the Chemical Research Department at this College, for help and advice when the chemical reactions of the cultures were being investigated, and Mr. Chapelow for providing potted plants for the experiments.

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" Dr. Alfred Fischer in the Rôle of Pathologist." Cent. f. Bakt., Abt. II., Bd. V., pp. 810-817 :
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WILTING OF RASPBERRY AND LOGANBERRY CANES.

By H. Wormald, A.R.C.Sc., D.I.C., B.Sc.

Samples of Loganberry and Raspberry canes showing premature wilting have been sent in to the College from time to time during the past two years. The canes were almost invariably grey in colour over small areas in some cases, in others over almost the whole surface, and these grey areas were dotted with fructifications of various microscopic fungi. As the diseased areas are at first quite localized, and since each of them bears as a rule but one of the species here described, with the exception mentioned below, it appears probable that some if not all of these forms are parasitic and directly responsible for the wilting.

At least four forms of fungus-fructifications have been found in the wilted canes that have come under observation :—

Hendersonia rubi, Westendorp, has been found on both Loganberry and Raspberry canes. The fruit bodies (pycnidia) to the naked eye appear as minute dots, but with a hand lens they are seen to be elliptical (see Plate XXIII., No. 2), the elongation being in a direction parallel with the axis of the shoot ; in this they are to be distinguished from the forms described below, which are always circular, or practically so, in surface view when examined with a lens. The reproductive bodies, or conidia, produced within the fructifications are brown in colour and transversely divided into several cells, usually four, of which the terminal ones are rather smaller than those towards the middle, and there is a slight constriction at each septum. Typical conidia measure 16—18×7—8μ. When placed in water germ tubes grow out readily from the larger central cells ; later the terminal cells may also give rise to

germ tubes (see fig. 1). This fungus has been described as a parasite on Raspberry and Loganberry canes,* and as preventive measures, spraying the young shoots with Bordeaux Mixture is recommended.

A second form, and one that has been of more frequent occurrence on the material examined than the *Hendersonia*

Fig. 1.
Germinating conidia of *Hendersonia rubi* × 500.

just described, is an ascomycete *Didymella applanata* (Niessl) Sacc. In this fungus the fruit-bodies (perithecia) are more or less flattened so that in taking a transverse section through the bark they appear elliptical (see Plate XXV., No. 1); in size they are usually about 175×120μ, but may vary from 148×110μ to 216×176μ, and each has a short beak which pierces the epidermis and communicates with the exterior.

The spores (*ascospores*) are produced in elongated sac-like cells (*asci*) growing from the base of each perithecium, and between the asci are delicate thread-like structures (*paraphyses*). The ascospores, of which there are eight in each ascus, are usually in two rows, and measure 14—19×6—9μ† ; they are two-celled with one cell (*i.e.*, that directed towards the apex of the ascus) a little broader than the other, slightly constricted at the septum dividing the two cells and are hyaline or lightly tinged with brown.

* See Leaflet No. 269 issued by the Board of Agriculture and Fisheries.

† In Saccardo's *Sylloge Fungorum*, the dimensions of the ascospores are given as 16 × 5—6μ.

If at maturity the perithecia are moistened the asci elongate to about twice their previous length, and, projecting beyond the surface of the bark of the host plant, forcibly eject the spores in rapid succession. On one occasion this process was observed under the microscope. As each spore was thrown out the one next below it advanced in such a way that the larger of the two cells of the spore became situated at the apex of the ascus, where it remained for a very short time before it was itself thrown out, when the process was repeated until all the eight spores had been dispersed.

Fig. 2.
Ascospores of *Didymella applanata* × 500.

Frequently associated with *Didymella applanata* but sometimes found alone is a fungus, the fructifications of which, when merely examined with a hand lens, resemble the last-named form. The spores (*conidia*) are not, however, produced in asci, but are borne simply on short stalks (*conidiophores*), which form a layer (*the hymenial layer*) lining the inner wall of the fructification; this hymenial layer, together with the wall of the fructification itself, is sometimes folded inwards as shown in Plate XXV., No. 4. The conidia are minute (2—3·5×3·5—7μ) and almost colourless. The fungus conforms with the description given of *Coniothyrium Fuckelii* Sacc., which has been described as producing a Raspberry Cane Blight in America where inoculations with pure cultures have proved the fungus to be parasitic and capable of producing the cane blight. The following quotations taken from Duggar's "Fungous Diseases of Plants" show the conclusions that the American workers have arrived at.

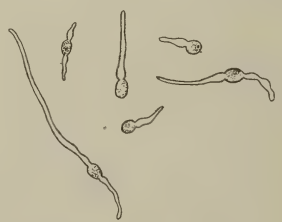

Fig. 3.
Germinating conidia of *Coniothyrium Fuckelii* × 500.

"The whole cane may be involved or only a portion of it. Often a single branch is killed while the remainder of the cane continues alive and apparently normal. In the majority of cases only a part of the cane dies. . .

" Clinton thinks that the raspberry cane blight fungus gains entrance through the flowers and young fruit, the spores apparently being spread by bees and other insects."

Coniothyrium Fuckelii is also parasitic on both wild and cultivated roses, producing on the stems, large, irregular cankers.*

This fungus is said to be the " imperfect " stage of the ascomycete *Leptosphaeria Coniothyrium* (Fuck.) ; the latter, though frequently found on dead twigs of species of *Rubus*† has not been observed on material examined at this College. As already stated the *Coniothyrium* is often found associated with the *Didymella*, and particularly have the two been found together on the old bases of the leaves, but whether there is any genetic connection between the two forms is a point that has not yet been investigated.

The three fungi above described have all been found on dead patches of bark on shoots which were still alive, as was shown by the fact that the leaves and flowering shoots both above and below the dead patches were, in many cases, still green, as may be seen in Plate XXIV.

Another form has been met with on a Loganberry cane, and though in this instance the cane was dead, the fungus appears to be identical with one that has been shown to be parasitic on one of the American blackberries, *Rubus nigrobaccus*, so it was thought advisable to give a description of the fungus here. Edgerton, who worked on the parasite in America, writes‡ :—

" It was not until the fruit was a little over half grown that the effect of the disease was noticed. Very suddenly, the leaves and the fruit above the spots wilted and dried up. The effect on the plant seemed to be that of girdling. The appearance of the canes was very similar to the cane blight of raspberries caused by a species of *Coniothyrium*. . . . The spots at this time were very evident, being two to five inches in length and completely encircling the stems, somewhat lighter in colour than the healthy regions and possessing a dry, dead appearance.

* *Journal*, Roy. Hort. Soc. Vol. XXXIV. p. 222.

† The genus includes the Raspberry, Loganberry and Blackberry.

‡ " Notes on a parasitic *Gnomonia*." Bull. Torrey Bot. Club, Vol. XXXIV. (1907), p. 593-597.

"An examination of the spots showed the presence of numerous black perithecial beaks, which appeared to the naked eye as small black setae, protruding through the dead cortex."

The same writer determined the microscopic character of the fungus, which proved to be *Gnomonia Rubi* Rehm, to be as follows :—

"The perithecia are subglobose, 200—260×175—220μ filled with the numerous asci. The asci are long-clavate 20—50×6—9μ and contain as a rule but four spores. . . . The spores are in one or two series, filling nearly the whole ascus, about 14—19×3—5μ. They are two-celled, the two cells being equal, constricted at the septum, somewhat fusoid, quite often guttulate.* Each end of the spore is continued into a long hyaline point, but this falls away very readily so that the end of the spore has a rounded appearance. Paraphyses are absent."

The form found on the Loganberry conforms with this description of *Gnomonia Rubi* except that the ascospores are rather smaller (12×3μ) and the hyaline appendages have not been observed, but it is possible that the specimens examined at Wye were not quite mature.

Edgerton was able to reproduce the disease by inoculations from pure cultures and writes in conclusion :—

"The results of this study seem to show that the fungus *Gnomonia Rubi* Rehm is a weak facultative parasite, a form that will grow rapidly as a saprophyte on the dead canes and will, if conditions are suitable, adapt itself to the living cane. It does not seem probable that it is a form that is liable to become a serious pest to blackberry canes, but rather one that may appear as a parasite only occasionally, only when the conditions are right."

Up to the time of writing only one cane bearing the fructification as described by Edgerton has come under our observation, and we have no evidence that the fungus is truly parasitic on either Loganberry or Raspberry canes in this country, but from the fact that the fungus is capable of producing a wilt on a closely allied host plant, growers are advised to examine wilted canes in order to ascertain whether

* *i.e.*, containing globules of oil.

this or any other fungus of known or suspected parasitic habits is present. *Gnomonia Rubi* is easily distinguished from the fungi already mentioned because of the beaked perithecia. If a portion of a cane bearing the fructifications be held up to the light and examined with a hand lens the beaks are seen projecting beyond the bark, appearing like small, black, scattered warts.

During the season of 1912 Loganberry shoots were noticed which showed elongated pale grey patches of bark, often several inches in length, dotted over with minute black specks which usually were not so sharply defined, when seen either with the naked eye or with a lens, as the fruit bodies of the forms mentioned above. Transverse sections made through the bark and examined with the microscope showed the black dots to be stroma-like tufts of fungal hyphæ which had burst through the epidermis; two of these are shown in Plate XXV., No. 2. No conidia have up to the present been observed on these stromata, and although an examination was made in the same plantation in 1913 this fungus was not found and its systematic position has not been determined.

The fungus *Ascochyta pallor* which is said to be parasitic on species of *Rubus* has not been observed on any of the material examined at Wye.

The first signs of the wilt disease as shown by the Loganberry may be seen on the young canes as early as July, when discoloured areas appear on the bark. These become more defined during August and September, but fructifications were not detected before October. The photograph on Plate XXIII., No. 1, shows a canker-like area with light grey, almost white bark, on a Loganberry cane, obtained on October 14th, 1913; the fructifications showing as black dots were found to be of the *Coniothyrium* type, as described on page 90. The fungus had invaded not only the cortex (bark) but also the wood and the pith, as shown by the browning (see Plate XXIII., No. 3) and by the presence of hyphæ in the vessels and cells of those tissues.

The discoloured patches of bark assume a greyish colour and may reach a considerable length, extending in a direction parallel with the axis of the shoot for some inches. In the case of the Loganberry the diseased canes often persist through

the flowering season but their development is retarded and the fruit either does not ripen or reaches maturity after the rest of the crop has been picked. The first three forms mentioned are to be found from October onwards until the canes are removed after fruiting, and spores capable of germination are to be obtained throughout the winter and spring.

As the mycelium of the various fungi is within the tissue of the host plant, in the bark or even in the wood and pith, spraying with fungicides is futile as a *remedy* when once the mycelium has gained an entrance. In one case that came under our notice, diseased Loganberry canes showing fructifications of *Hendersonia rubi* and *Coniothyrium Fuckelii* had been winter-sprayed with lime-sulphur wash and portions of these sprayed shoots, with the dry wash still on them, were subsequently sent in to the College (January, 1913) that the viability of the spores might be tested. Spores of both fungi were found and they were apparently uninjured, but the convincing proof that they were still alive lay in their power of germination when set up in hanging drops. Both kinds of spores germinated readily, proving not only that living spores, capable of producing germ tubes, are produced during the winter months, but also that they remained uninjured by the spray. Figs. 1 and 3 were drawn from hanging drops containing conidia obtained from fructifications on the sprayed canes.

Spraying experiments with lime-sulphur wash as a *preventive* during the growth of the canes were performed during the summer of 1913, but no definite conclusions regarding the value of the spray against this disease have yet been reached. It was shown, however, that the lime-sulphur wash at ordinary summer strength (1.01 S.G.) may be used on Loganberry bushes without risk of spray injury.

It is advisable to remove and burn promptly all diseased canes immediately after the fruit has been picked.

Another form of raspberry cane wilt has come under our notice during the past year. In this case the whole of the lateral (flowering) shoots of one or more of the canes at the same root, become wilted and the leaves droop. Usually

this occurs early in the season ; such shoots may fail soon after they begin to elongate or they may reach the flowering stage before they show signs of withering. Diseased plants of this type were first sent to the College on June 5th, 1913, and between that date and July 7th, similar material was received from three widely separated plantations in Kent and Surrey.

Some of the canes showed the fructifications of *Didymella applanata*, while others were apparently quite free from fungi on the canes themselves although an examination of the roots revealed almost invariably, at the crown of the plant, the presence of white fungous outgrowths bearing numerous sickle-shaped spores (conidia) of the type referred to the genus *Fusarium*. This form was sometimes to be seen on exposing the roots as the plants were lifted from the soil, in others it appeared in from two to five days, provided that the roots were kept in a damp atmosphere, *e.g.*, by placing them on damp blotting paper in a large petri dish.

The conidia of this fungus are abstricted from the white pustules (*sporodochia*) which are to be found bursting through the cortex of the roots a few inches below the ground level, and sometimes on the bases of the canes themselves. From one root conidia were obtained from a pustule situated seven inches below the base of the canes.

The dimensions of the conidia are typically about $36 \times 6\mu$, but the length may vary from 32-40μ. Each conidium has, as a rule, two septa, dividing it traversely into three cells ; the septa are rather inconspicuous, but the divisions are usually indicated by a highly refractive globule which may be seen at or near the centre of each cell (see Fig. 4). A typical conidium is somewhat attenuated towards one extremity (indicating the point of attachment before its abstriction), the cell there being rather longer and narrower than the other cells of the conidium. Only rarely were three septa to be seen, while the smaller conidia had often but one septum each.

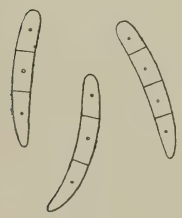

Fig. 4.
Conidia of a *Fusarium* obtained from diseased Raspberry roots × 500.

A *Fusarium*, suspected of being parasitic on the Raspberry, but which, in inoculation experiments has given only

negative results, was observed on the roots of dying Raspberry plants in Switzerland during the summer of 1911, and described by Osterwalder.* It is considered to be the conidial stage of an ascomycete, *Nectria Rubi*, which was also found on the roots of the diseased Raspberries.

The conidia (as obtained from the diseased roots) of the *Fusarium* described by Osterwalder are similar in general shape to those obtained from the form growing on the Raspberry roots obtained from Kent and Surrey; they are, however, generally larger (42.5—61.2×6.6—7.9μ),* they usually have three septa, and are borne on violet-coloured pustules.

The wilting of Raspberry and Loganberry canes appears to be fairly distributed throughout the country as is shown below :—

Loganberry canes with *Didymella applanata* and *Coniothyrium Fuckelii* have been received from Maidstone, Kent, from Woodnesborough, Kent, and from Worcestershire ; with *Hendersonia rubi* from near Maidstone.

Raspberry canes bearing *Didymella applanata* and *Coniothyrium Fuckelii* have been sent in from Blairgowrie, N.B. (in 1911), with *Hendersonia* from Bramley, Surrey.

Gnomonia rubi has been found up to the time of writing only on a Loganberry cane obtained from near Maidstone.

The *Fusarium* has been obtained on the roots of Raspberries from Woodnesborough, Kent, from Warlingham, Surrey, and from Bramley, Surrey.

* *Osterwalder, A.*, " Über eine neue auf kranken Himbeerwurzeln vorkommende Nectria und die dazu gehörige Fusarium-Generation." (Berichte Deutsch. Botan. Gesellsch. Band XXIX., pp. 611-622. Berlin, 1911.)

NOTE ON *RHIZOPUS NIGRICANS.*

By H. Wormald, A.R.C.Sc., D.I.C., B.Sc.

An article on "The *Rhizopus*-rot of Tomatoes" appeared in the last number of this *Journal*, and there it was proved that *Rhizopus nigricans* is capable of rapidly producing a soft rot of the internal tissues of the tomato fruit on gaining entrance through wounds in the skin. In that article it was stated that this fungus produces thick-walled resting spores (zygospores) which are formed only when two strains, the (+) and the (—) forms are growing together. The following statement also appeared*: "No zygospores have yet been found on the material at Wye, and since all the cultures were derived originally from a small portion of mycelium obtained from a diseased tomato it is to be presumed that they are all of one strain, but whether (+) or (—) has not yet been ascertained."

Since then tube cultures of the (+) and (—) strains have been obtained from the *Bureau pour la distribution de Cultures de Moisissures* at Amsterdam, for comparison with the Wye strain. Another unknown strain was received from South Kensington; this was kindly sent by Mr. C. West, who obtained the strain by exposing a piece of bread in a laboratory at the Royal College of Science, and prepared a tube culture from the resulting growth.

The four strains (*i.e.*, the named (+) and (—) strains from Amsterdam, the South Kensington strain and the original one used in the inoculation experiments described in the last number of this *Journal*) were simultaneously inoculated into tomatoes, all of which soon acquired the characteristic rot, thus proving that all four strains of the fungus were equally capable of producing the rot.

These strains were then employed in the following experiments, which were carried out in an endeavour to induce the development of zygospores.

* Vol. XXI., p. 390.

Nutrient agar, prepared from an extract of prunes, was poured while hot into four sterilized petri dishes and allowed to cool. In this way a thin layer of the jelly-like agar was obtained in each dish. The dishes were numbered and spores from two strains of *Rhizopus nigricans* were placed in each. The method of inoculation was as follows :—

A flamed platinum loop was dipped in sterilized water and the small drop of water retained in the loop was brought in contact with one or more sporangia of the culture. The water caused the rupture of the sporangia ; the spores were thus liberated and received into the drop of water which was then transferred to the agar and placed about 2.5 cm. from the centre of the dish. After flaming the wire in order to destroy any spores still adhering to the loop, spores were obtained from a second culture in the same way, and placed in the same dish, but on the opposite side of the centre, so that the two groups of spores were approximately 5 cm. apart.

Dish No. 1 was inoculated from the (+) strain and from the (—) strain.

Dish No. 2 was inoculated from the Wye strain and from the (+) strain.

Dish No. 3 was inoculated from the Wye strain and from the (—) strain.

Dish No. 4 was inoculated from the Wye strain and from the strain obtained from South Kensington.

All four were placed in an incubator at a temperature of 26° C.

Within forty-two hours the spores had germinated and produced mycelium which in Dishes No. 1, 2 and 3 had reached the centre of the plates (*i.e.* 2.5 cm. from the point of inoculation in each case), and the two strains in each plate had, in consequence, come into contact with one another. In No. 4 growth had taken place less quickly, but even here the mycelium had reached to 1.5 cm. from the points of inoculation.

After sixty hours mature (black) sporangia were found in Nos. 1, 2, and 3, while in No. 4 the two mycelial masses had now come in contact in the centre of the plate ; four hours later mature sporangia were found in the latter culture also, while in No. 2 the early stages of zygospore formation were to

be seen together with a few immature zygospores. Later zygospores were produced in Nos. 1 and 4, but not in No. 3.

Thus zygospores were obtained by growing together

(*a*) the (+) strain and the (—) strain,

(*b*) the (+) strain and the Wye strain,

(*c*) the strain from South Kensington and the Wye strain but no zygospores have been observed by growing together the Wye strain and the (—) strain.

Rhizopus nigricans. Stages in the development of zygospores × 100.

The conclusions to be drawn are: (1) the Wye strain is identical with the (—) strain, since it will conjugate with the (+) strain but not with the (—); (2) the strain obtained from South Kensington on the other hand is the (+) form since zygospores are produced by growing it with the Wye, *i.e.* (—), strain.

Some months later the experiments were repeated, using fresh cultures from the Amsterdam Centralstelle, and sub-cultures from the original Wye and South Kensington strains. The cultures on this occasion were kept at ordinary room temperature (about 16°C.) and in consequence growth was not

so rapid as in the previous experiments. Zygospores in various stages of development were, however, produced within seven days, except (as before) where the Wye strain and the (—) strain were grown together.

The accompanying figure shows stages in zygospores development produced by the cultures obtained in the second set of experiments.

I wish to thank Mr. C. West, A.R.C.Sc., D.I.C., B.Sc., of the Imperial College of Science and Technology, for preparing and forwarding the original cultures of the South Kensington strain of *Rhizopus nigricans.*

THE COMPARATIVE SUSCEPTIBILITY OF VARIETIES OF SWEDES AND TURNIPS TO THE "SWEDE MILDEW"

(*Erysiphe polygoni* D.C.).

By G. O. Searle, B.Sc.

During the summer of 1913 a number of plots of Swedes, Turnips and Rape were grown to test the comparative susceptibility of various varieties to Swede Mildew (*Erysiphe polygoni* D.C.).

Samples of thirty-three varieties of Swedes, forty-two varieties of Turnips, and two varieties of Rape were obtained from five well-known seed merchants in England and Scotland.

The plots measured ten links square, *i.e.*, one-thousandth of an acre each, and each plot had five rows of plants, *i.e.*, two links apart with the space of one link between the outside row and the outside of the plot.

Owing, however, to limited space, twenty-six varieties were relegated to smaller plots, and were grown in single rows, each five yards long. In order to make the weights of these smaller plots roughly comparable with the fifty-one main plots, they have, in the following table of results, been multiplied by eleven-fifths, since a row of plants five yards long is five-elevenths of a plot ten links square, containing five rows. The varieties in these smaller plots were chiefly ones identical in name with others in the main plots, the only difference being that they came from different seedsmen.

The fifty-one main plots were arranged in three groups of seventeen plots each, running the length of the ground used, the rows of plants being continuous through each line of seventeen plots. Between each group ran a path two links

wide, and also between the outside group and the twenty-six smaller plots, the rows of which also ran up and down the length of the land.

As far as possible, the plots of Swedes, Turnips, and Rape were all mixed one with another in order to give all the plots the maximum opportunity of uniform infection. All the plots were sown by hand during the three days, June 9th, 10th and 12th.

Previously to this, viz., on May 12th and 23rd, plots of mixed seed, each approximately twenty-five square yards, had been sown to provide, if possible, material for carrying out the inoculations, as farmers commonly hold the theory that if Swedes and Turnips are sown earlier than the beginning of June the attack of mildew will be more certain and more severe.

However, the theory was found not to apply in the present case, as these two early plots did not become attacked earlier or more severely than the main crop of Swedes on the farm, from which finally the material for inoculation was obtained.

During the succeeding month or so the plots were thinned and cultivated in the usual way.

The mildew first appeared in the greenhouse on some Swedes in pots on July 23th, but there was not sufficient material to spare from the series of indoor inoculations, which were being carried on, to allow of the plots being inoculated then.

Finally, on August 23rd, the mildew appeared on the main crop of Swedes on the farm ; on August 28th a large number of infected leaves were picked and brought into the laboratory, where they were placed in a warm, moist atmosphere to encourage the formation of a large number of conidia.

On August 29th these leaves were washed in large cans of water, after which the water was found to have quite a milky appearance from the large number of conidia it contained. This water was then sprayed as evenly as possible all over the plots with a fine rose.

The weather at the time was dull, but no rain fell for three or four days, so the conidia had ample time to germinate successfully and infect the leaves.

Before the inoculation was carried out a very careful

search for a natural infection was made, but no trace of mildew could be found on any plot. The mildew was first noted on the plots on September 2nd, when, after careful examination, a few minute patches of mildew were found to be present on very nearly every plot.

From September 6th onwards, the amount of mildew present was classified, once a week, in the following manner : Marks were assigned each week to each plot, these marks varying from 0-10 according to the severity of the attack ; the plots marked 0 were those on which no traces of fungus could be found, and so on proportionately up to 10 assigned to the plots most severely attacked, and on which not a single leaf could be found free from mildew.

Although this method for the estimation of the amount of disease present was open to a certain amount of error, since it was based on the relative appearance of the plots as noted by the eye, it was found in practice, that it was comparatively simple to place any given plot in its proper class with only a very small error.

On October 9th the last estimate was made as the attack seemed by then to have attained its maximum severity ; from that date onwards new leaves, as they were formed, were only slightly attacked and the plants grew well.

On November 3rd all the plots were pulled, the roots topped and cleaned, and then weighed in a basket on a spring balance. On an average the plots contained fifty roots each.

It will be noted from the following table that every plot was attacked to a certain extent, so that no variety could be marked as low as 0.

As will be seen, from the table given below, the Swedes were attacked more severely than the Turnips, though the latter were sometimes badly attacked, but do not show it to an equal extent, since the greatest growth of mildew is on the lower side of the leaf ; this fact was taken into account in estimating the severity of attack.

To obtain, as far as possible, comparative results, all the varieties were sown and pulled at the same time ; in consequence some of the softer and earlier varieties of turnips became over ripe and suffered more or less severely from

various kinds of rot; this caused an interference with the estimation of the crop, though it had no effect on the estimation of the disease, as the rotting did not occur till the last week or so before pulling and after the disease estimations had been finished.

In a letter from Messrs. Drummond & Sons, these seedsmen state that, in their experience in the North, the bronze top Swedes are more liable to mildew than the purple or green top varieties; also that purple top yellow is more susceptible than green top yellow, and that their Improved Bronze Top was the best in this respect.

From the table it will be seen that this Improved Bronze Top (No. 40) became the most severely attacked of all their sixteen samples. No. 11, a green top, proved very susceptible, but No. 14, also a green top, was only slightly attacked, whilst No. 31, Irvine's Disease Resisting Swede, quite belied its name.

In the following table are given, the number of the plot, origin of seed, name of variety, weight of crop in lbs., the marks estimating the severity of the attack, an average of these marks, and some general remarks including shape, and the varieties of Turnips attacked by rot.

It must be borne in mind that the results recorded are those of only one year, and of a year when Swedes generally were badly attacked by mildew in this district; the same varieties will again be grown in the same sized plots and under similar conditions this year. It will be best, therefore, to await the results of the 1914 trials before making an estimate of the comparative susceptibility of the different varieties.

Plot Results, 1913.

No. of Plot.	Name of Seedsman.	Variety.	Weight of Crop. (1/1000th acre.)	Severity of attack. Weekly figures (see p. 103).						Average of Weekly figures.	Remarks.
		SWEDES.	lbs.	1st.	2nd.	3rd.	4th.	5th.	6th.		
1	Sutton	Magnum Bonum Swede	58	4	2	2	4	5	4	3½	Tankard.
3	,,	Improved Lord Derby Swede ..	50	5	4	4	4	4	4	4⅙	Round.
8	,,	Up-to-date Swede	50	8	9	10	10	10	10	9½	Round.
9	,,	Champion Swede	57	8	7	7	7	9	9	7⅚	Round.
10	,,	Hardy White Swede	53	6	5	6	7	7	7	6⅓	Round.
11	,,	Green Top Swede	48	10	9	9	9	9	9	9⅙	Tankard.
12	,,	Queen Swede	53	10	9	9	8	9	9	9	Tankard.
13	,,	Crimson King Swede	55	4	4	4	5	8	9	5⅔	Tankard.
14	,,	Centenary Hybrid Green Top Swede	43	1	3	3	3	2	2	2⅓	Round—Flat.
24	Austin and McAslan	X-L All Swede	50	4	7	7	6	7	7	6⅓	Round.
25	,,	Best of All Swede	54	5	4	6	7	9	9	6⅔	Round.
26	,,	Elephant Swede	57	2	4	5	5	8	8	5⅓	Round.
27	,,	Webster's Swede	41	8	6	7	6	8	7	7	Round.
28	,,	Drummond's Swede	55	7	7	7	6	8	8	7⅙	Round.
29	,,	Austin's Eclipse Swede	52	6	5	7	5	7	6	6	Round.
30	,,	Austin's St. Mongo Swede	53	5	5	6	5	8	8	6⅙	Round.
31	,,	Irvine's Disease Resisting Swede ..	22	5	4	5	6	8	8	6	Round. Germination capacity seemed poor.
32	,,	Austin's Clydesdale Swede	41	7	5	6	6	7	7	6⅓	Round.
33	,,	Supreme Swede	35	4	4	4	5	6	5	4⅔	Round.
34	,,	Kangaroo Swede	46	4	5	5	6	8	9	6⅙	Round.
35	Drummond	Stirling Castle Swede	40	4	5	4	3	4	4	4	Tankard.
36	,,	Extra Improved Swede	43	7	6	6	6	6	6	6⅙	Tankard.
37	,,	Monarch Swede	48	3	6	5	6	6	7	5½	Tankard.
39	,,	New Cross 1908 (Purple Top Swede)	48	6	6	6	6	6	6	6	Tankard.
40	,,	Improved Bronze Top Swede ..	51	6	9	9	9	8	7	8	Round.
43	,,	New Cross, 1912 (Purple Top Swede	52	4	6	6	7	8	8	6½	Round.

No. of Plot.	Name of Seedsman.	Variety.	Weight of Crop. (1/1000th acre.)	Severity of attack. Weekly figures (see p. 103).						Average of Weekly figures.	Remarks.
			lbs	1st.	2nd.	3rd.	4th.	5th.	6th.		
44	Little and Ballantyne	Carlisle Castle Bronze Top Swede ..	50	7	9	7	8	8	9	8	Round.
47	,,	Knowefield Purple Top Swede ..	44	6	6	6	7	7	8	$6\frac{2}{3}$	Round.
48	,,	Lonsdale Green Top Swede	32	5	5	5	6	7	8	6	Round.
56	Austin and McAslan	Hardy Green Top Swede	61	5	5	4	5	6	7	$5\frac{1}{3}$	Round.
63	Drummond	Best of All Swede	57	2	3	4	3	7	9	$4\frac{2}{3}$	Round.
64	,,	Hardy Green Top Swede	44	7	7	8	6	6	9	$7\frac{1}{6}$	Round.
68	Little and Ballantyne	Monarch Purple Top Swede	40	2	2	4	4	7	8	$4\frac{1}{2}$	Long.
70	,,	Best of All Purple Top Swede ..	35	3	3	3	4	6	8	$4\frac{1}{2}$	Tankard.
		TURNIPS.									
2	Sutton	Long Keeper Aberdeen Turnip ..	42	0	1	2	4	5	4	$2\frac{2}{3}$	Round. Large proportion rotted.
4	,,	Perfection Green Top Aberdeen Turnip	30	1	1	1	1	1	1	1	Round. Large proportion rotted.
5	,,	Yellow Tankard Turnip	61	2	3	4	4	4	4	$3\frac{1}{2}$	Tankard.
6	,,	Selected Fosterton Turnip	59	2	3	4	5	4	3	$3\frac{1}{2}$	Flat. Some rotted.
7	,,	All-the-Year-Round Turnip	75	2	4	4	5	5	5	$4\frac{1}{6}$	Flat.
15	,,	Early Sheepfold Turnip	62	1	3	2	2	4	2	$2\frac{1}{3}$	Tankard.
16	,,	Early Six-Week Turnip	68	2	4	3	3	4	2	3	Flat.
17	,,	Pomeranian White Globe Turnip ..	88	2	4	4	4	6	5	$4\frac{1}{6}$	Round.
18	,,	Red Paragon Turnip	96	1	1	1	4	4	5	$2\frac{2}{3}$	Long.
19	,,	Greystone Turnip	81	1	2	2	4	4	5	3	Tankard
20	,,	Purple Top Mammoth Turnip ..	100	1	1	1	4	4	5	$2\frac{2}{3}$	Tankard. One or two rotted.
21	,,	Hardy Green Round Turnip ..	57	1	2	3	3	4	4	$2\frac{5}{6}$	Round.
22	,,	Imperial Green Globe Turnip ..	77	1	3	4	4	4	3	$3\frac{1}{6}$	Round. Some rotted.
38	Drummond	Stobo Blue Yellow Turnip	56	3	3	4	7	6	6	$4\frac{5}{6}$	Tankard. Some rotted.
41	,,	Purple Top Yellow Turnip	34	2	5	5	8	8	6	$5\frac{2}{3}$	Round. Most rotted.

42	Drummond	Improved Aberdeen Green Top Yellow Turnip.	50	2	4	4	6	6	6	4⅔	Round. Most rotted.
45	Little and Ballantyne	White Globe Turnip	72	4	6	5	8	7	7	6⅙	Round.
49	Carter	Re-selected Red Globe Turnip ..	78	2	3	2	4	4	4	3⅙	Round.
50	,,	Improved Purple Top Mammoth Turnip	71	1	2	1	2	3	2	1⅝	Round.
51	Carter	Improved Red Paragon Turnip ..	80	1	2	2	4	4	4	2⅚	Round.
52	Sutton	Favourite Purple Top Aberdeen Turnip	44	1	2	2	4	6	6	3½	Tankard. Some rotted.
53	,,	Purple Top Aberdeen Turnip	35	1	2	3	7	6	6	4⅙	Round. Large proportion rotted.
54	,,	Green Top Aberdeen Turnip	46	1	2	1	3	3	3	2⅙	Long. Some rotted.
55	Austin and McAslan	White Globe Turnip	58	1	2	2	4	5	4	3	Round. One or two rotted.
57	,,	Fosterton Hybrid Yellow Turnip ..	57	1	2	1	1	1	4	1⅔	Round.
58	,,	Aberdeen Green Top Yellow Turnip	51	1	1	1	1	1	1	1	Round.
59	,,	Mammoth Purple Top White Turnip	75	1	2	1	2	3	5	2⅓	Tankard.
60	Drummond	Purple Top Mammoth White Turnip	78	1	1	1	1	2	2	1⅓	Tankard.
61	,,	Improved Early Yellow Turnip ..	46	1	3	2	3	2	3	2⅓	Round. Some rotted.
62	,,	Fosterton Hybrid Yellow Turnip ..	44	1	2	3	4	4	5	3⅙	Round.
65	,,	Pomeranian White Globe Turnip ..	44	1	2	2	3	3	2	2⅙	Round. Some rotted.
66	,,	Green Globe Imperial White Turnip	106	2	2	1	3	2	2	2	Round. One rotted.
67	Little and Ballantyne	Fosterton Hybrid Yellow Turnip ..	40	1	1	1	1	2	2	1⅓	Round. Some rotted.
69	,,	Green Globe White Turnip	84	1	7	6	7	7	6	5⅔	Round.
71	,,	Purple Top Mammoth White Turnip	62	1	2	2	2	4	3	2⅓	Tankard.
72	,,	Aberdeen Green Top Yellow Turnip	31	2	3	2	3	2	3	2½	Round.
73	,,	Chieftain Green Top Yellow Turnip	88	2	2	1	2	2	3	2	Round.
74	Carter	Imperial Green Globe Turnip ..	95	2	2	1	2	3	2	2	Round. One rotted.
75	,,	Devonshire Greystone Turnip ..	106	1	2	1	3	5	4	2⅔	Flat.
76	,,	Pomeranian White Globe Turnip ..	101	2	5	6	6	6	6	5⅙	Round.
77	Austin and McAslan.	Purple Top Yellow Turnip ..	77	1	4	5	6	6	6	4⅔	Tankard.
		RAPE.									
23	Austin and McAslan	Broad Leaved Sowing Rape ..	—	4	4	5	4	8	8	5½	—
46	Little and Ballantyne	Broad Leaved Rape	—	8	8	7	7	8	9	7⅚	—

INFECTION-EXPERIMENTS WITH THE POTATO "BLIGHT" FUNGUS.

(*Phytophthora infestans*).

By G. Smith, B.Sc.

In his recently published book "Potato Diseases in Australia," Professor D. McAlpine states that *Phytophthora infestans*, lately introduced into Australia, has proved capable of infecting *Solanum aviculare*, a common Australian weed. It seemed of interest to ascertain whether the fungus as it occurs in this country would be able to infect at once *S. aviculare*, or whether it required a process of gradual adaptation. For inoculation experiments, healthy plants of *S. aviculare* were raised from seed (obtained from Vilmorin, of Paris), in a cool glass-house and these plants remained throughout the summer free from disease. In August, the blight appeared in the potato crop on the Farm; from this material suspensions of sporangia were obtained, and healthy potato leaves and potato slices were inoculated. The fungus developed rapidly and on both substrata produced sporangia in abundance and in a pure state. Plants of *S. aviculare* and potato leaves were inoculated in the evening with a suspension of sporangia, and were kept under bell-jars for twenty-four hours in order to give the sporangia favourable conditions for germination. Other plants were kept under similar conditions as controls. The potato leaves developed the disease and sporangia were produced in a few days, but *S. aviculare* was slower in developing the symptoms, and it was not until the twelfth day that sporangia were produced on the leaves. The control plants remained perfectly healthy. The experiment was repeated and the same results were obtained.

In text-books the common English weed *S. dulcamara* is given as a host-plant of *Phytophthora infestans*. It is obviously of economic importance in connection with the persistence

from year to year, and also with the spread of Potato blight, to know whether the fungus can freely pass from this plant to the potato and *vice versâ*. Experiments on this point do not seem to have been recorded. Repeated attempts were made to infect *S. dulcamara* (and also *S. nigrum*) with the sporangia from the potato, but always without success. Other species of *Solanum*, and also *Physalis* and some other plants were inoculated with negative results (see table below). In carrying out these experiments the young plants in small pots of soil were placed under a cloche and arranged so that they were not in contact. Under each cloche so used a healthy potato shoot was placed, inoculated with the same suspension as the other plants, and kept as a control under the cloche for the same length of time.

The potato leaves in each case were infected with the fungus, but the other plants remained free from it.

For the purpose of obtaining material for inoculation, *S. dulcamara* was planted in the College Botanic Garden. On September 13th, on a plant situated in a shady corner of the Garden I observed a few leaves which were darkened in patches and thus bore a striking resemblance to a "blight" attack. No sporangia were observed on these leaves, but on being placed in a moist chamber in the laboratory, they developed them. During the week following, sporangia were produced on the leaves on the one plant in the shady corner, but not elsewhere. With the limited amount of sporangia available, slices of potato, and also potato leaves, were inoculated and kept under suitable conditions with controls. No infection resulted on the potato leaves but the slices, with a few exceptions, produced sporangia of *Phytophthora*, the controls remaining free.

Inoculations with Sporangia of *Phytophthora infestans*.

No. of Expt.	Origin of Sporangia.	Plant inoculated.	Result.
1	Potato.	*Solanum aviculare*	+
		Potato	+
2	Potato ..	*Physalis edibulis*	—
		Physalis lanceolata	—
		Solanum aviculare	+
		Potato	+

No. of Expt.	Origin of Sporangia.	Plant inoculated.	Result.
3	Potato ..	*Solanum robustum*	—
		S. capsipistrum	—
		Egg-plant	—
		Potato	+
4	Potato ..	*Nicandra physaloides*	—
		Hyocyamus niger	—
		Physalis Bunyardi	—
		Potato	+
5	Potato ..	*Datura stramonium*	—
		Solanum balbisii	—
		Potato	+
6	Potato ..	*S. dulcamara*	—
		Physalis alkekengi	—
		P. Franchetti	—
		Potato	+
7	Potato ..	*S. nigrum*	—
		Tomato (leaf and fruit)	—
		Potato	+
8	Potato ..	*S. nigrum*	—
		S. dulcamara	—
		Potato	+
9	*S. dulcamara*	*S. dulcamara*	+
10	*S. dulcamara*	Potato (leaf)	—
		Potato (cut tuber)	+

Conclusions.

The spores of *P. infestans* on Potato in this country are able to infect *Solanum aviculare*, as has been found to be the case in Australia. Negative results were obtained with the fungus on Potato when sown on *Tomato*, *S. dulcamara* and *S. nigrum.*

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PLATE I.

[*W. H. Hammond, photo.*

Gooseberries (*Cousin's Seedling*) all except one attacked by the American Gooseberry-Mildew. The healthy berry shows the size to which the others should have grown if healthy. The smaller berries are completely invested with the brown mycelium.

PLATE II.

[*W. H. Hammond, photo.*

End of a gooseberry shoot (*Berry's Early*) severely attacked by the American Gooseberry-Mildew. The uppermost leaves have been so severely attacked that they have not grown out. These young distorted leaves are completely covered over with the brown "winter-stage" of the mildew, and on falling to the ground infest the soil.

PLATE IV.

[*W. H. Hammond, photo.*

Apples attacked by the "Brown Rot" fungus.

PLATE V.

[*W. H. Hammond, photo.*

Dried-up "mummied" apples, bearing the "Brown Rot" fungus. These apples (of the previous year's growth) were taken from an apple tree when in flower.

PLATE VI.

[*W. H. Hammond, photo.*

A small "canker" formed by the "Brown Rot" fungus.

PLATE VII.

[*W. H. Hammond, photo.*

A small "canker" formed by the "Brown Rot" fungus.

PLATE VIII.

[*W. H. Hammond, photo.*

Pustules of spores of the "Brown Rot" fungus.

PLATE IX.

[*W. H. Hammond, photo.*

Pustules of spores of the "Brown Rot" fungus.

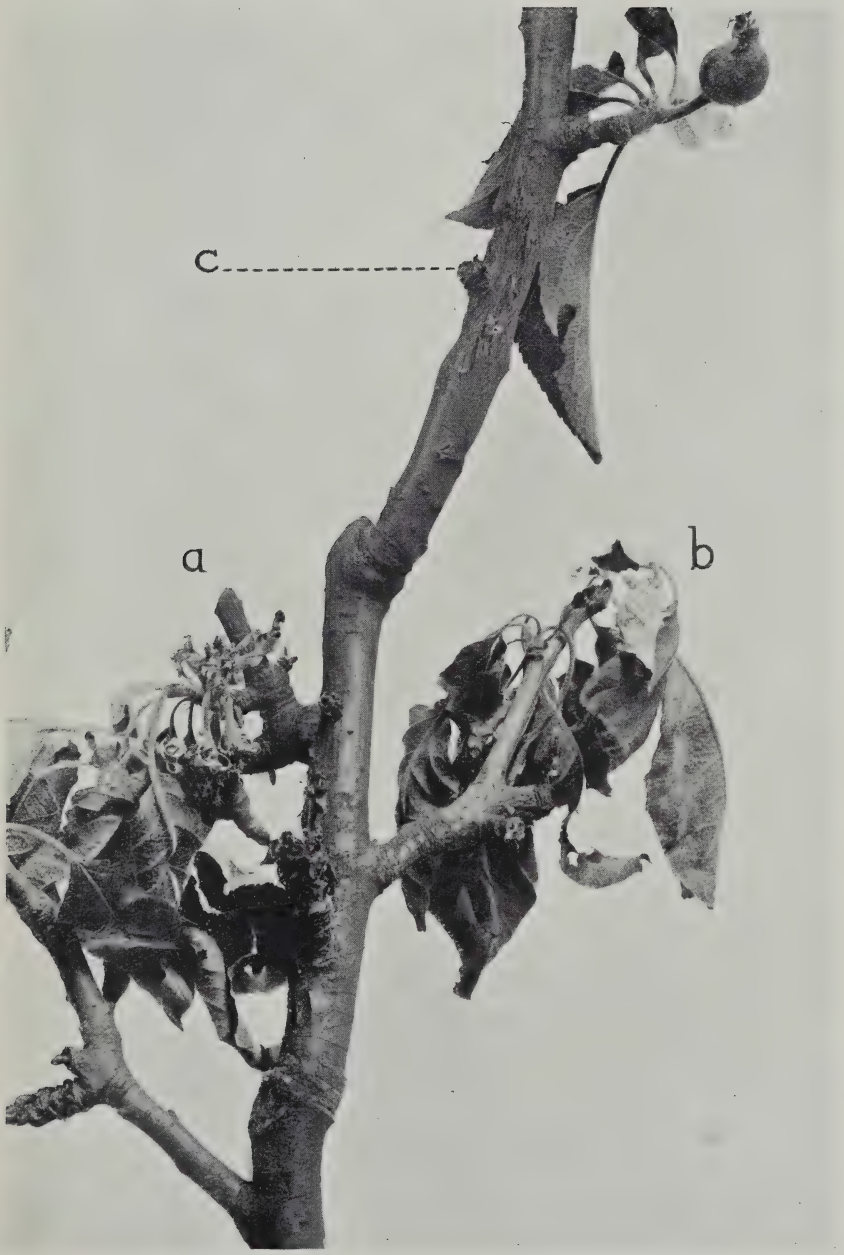
"Canker" produced by the "Brown Rot" fungus on a branch of "James Grieve."

Portion of the "canker" shown in *Plate* 10. Pustules of spores of the "Brown Rot" fungus can be seen in cracks in the bark.

Portion of branch of Cox's Orange Pippin; the flower-spurs at *a* and *b* have been attacked and killed by the "Brown Rot" fungus.

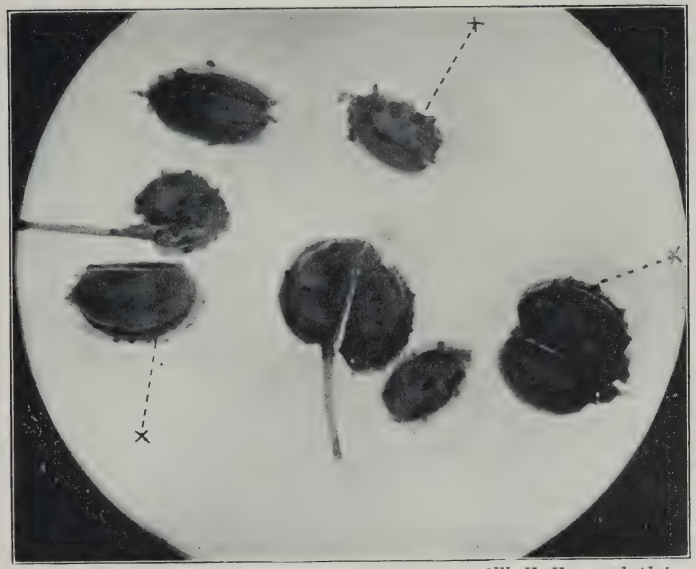
Portion of branch of Cox's Orange Pippin ; the " Brown Rot " Fungus, entering through the flower-spurs (as at *a*) has caused a " canker."

The same branch as in *Plate* 13, seen from the opposite side. The branch is almost girdled by the "canker"; pustules of spores are appearing in the cracks in the bark



"Brown Rot" canker in a branch of Cox's Orange Pippin; the remains of the dead spur where the fungus entered can be seen at *c*. Fresh shoots have been attacked at *a* and *b*.

PLATE XVI.



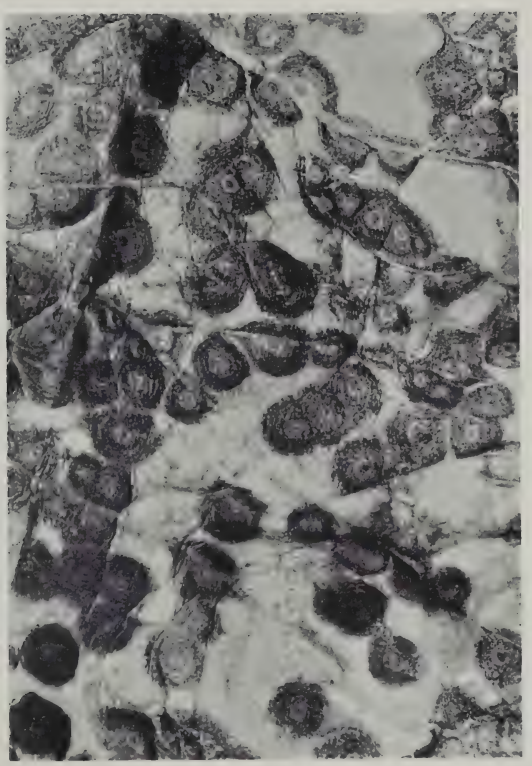
[*W. H. Hammond, photo.*

Photomicrograph of diseased Celery Seeds, showing (as at *x*) the fruit-conceptacles (*pycnidia*) of the fungus *Septoria* (magnified).

PLATE XVII.

[*H. Wormald, photo.*

Portion of a root showing the white strands of *mycelium* of the "White Root Rot" fungus.



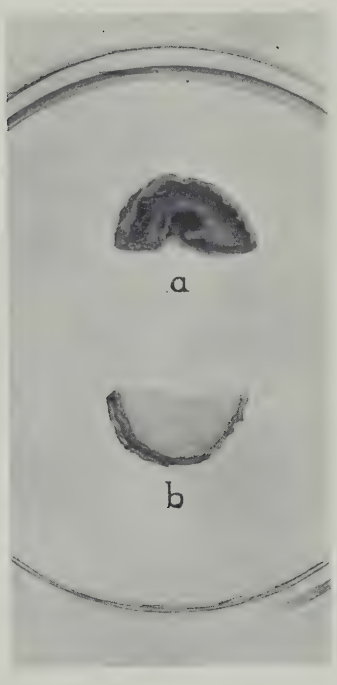
[*H. Wormald, photo.*

Portion of Broccoli-leaf, showing "Leaf-spot."

[*H. Wormald, photo.*

Naturally infected Celery showing inner leaves with "soft-rot"—outer leaves removed.

No. 1.



No. 2.

[*H. Wormald, photo.*

No. 1. Naturally infected Celery "heart" with "soft-rot."

No. 2. A slice of Celery "heart" cut into halves, one (*a*) inoculated from a pure culture, the other (*b*) control, showing result four days after (*a*) was inoculated.

[*H. Wormald, photo.*

A Celery plant two days after the leaf on the left was inoculated ; the leaf on the right was the control, *i.e.*, similarly wounded but not inoculated.

PLATE XXII.

No. 1.

No. 2.

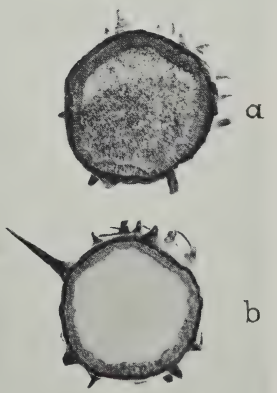
No. 3. [*H. Wormald, photo.*

Cultures of *Bacillus apiovorus*.

No. 1. A "poured-plate" culture.
No. 2. A "stab" culture in nutrient gelatin; 20 hours after inoculation.
No. 3. Complete liquefaction of the gelatin after 12 days.

No. 1.

No. 2.



No. 3. [*H. Wormald, photo.*

No. 1. Loganberry cane showing at *a* a "canker" with *Coniothyrium* Fuckelii; at *b* is an incipient canker.

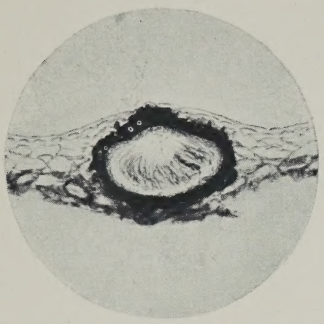
No. 2. Loganberry cane with fructifications of *Hendensonia rubi* × 1½.

No. 3. Sections of the cane shown in No. 1. *a* taken through the canker and *b* at one inch above it.

[*H. Wormald, photo.*

Loganberry cane with fructifications of *Didymella applanata*.

PLATE XXV.



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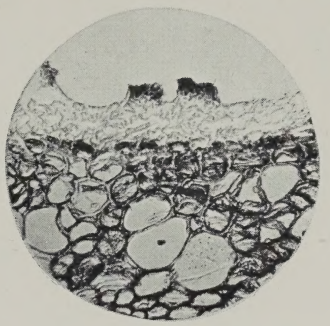

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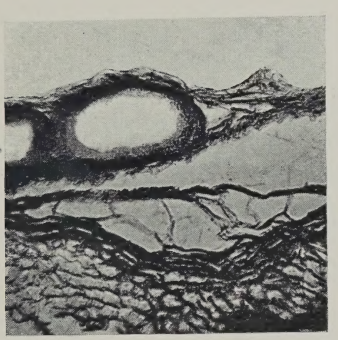
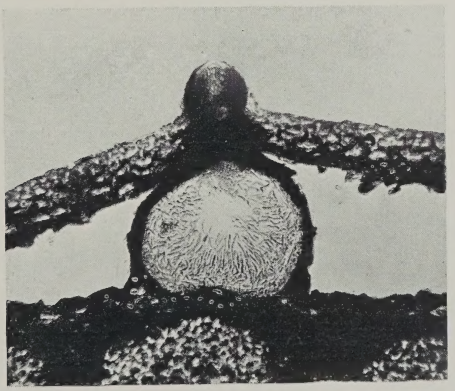


No. 3.

No. 4.



No. 5. [*H. Wormald, photo.*

Fungi seen in transverse sections of Loganberry canes:

(1) *Didymella applanata*, × 100. (2) Sclerotia-like bodies of a fungus not identified, × 100. (3) and (4) *Coniothyrium Fuckelii*, × 100. (5) *Gnomonia rubi*, × 80.

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